Appendix G
Non-fishing Impacts to Essential Fish Habitat and Recommended Conservation Measures

Prepared by

National Marine Fisheries Service

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This appendix to the Alaska Essential Fish Habitat Environmental Impact Statement was adapted from a document developed jointly by the National Marine Fisheries Service Alaska Region, Northwest Region, and Southwest Region, and it was revised to apply specifically to Alaska. The following people contributed to this document (listed in alphabetical order): Lt. Mark Boland, Mark Carls, Eric Chavez, Bryant Chesney, Brian Cluer, Tracy Collier, Natalie Consentino-Manning, Joe Dillion, Bob Donnelly, Jeanne Hanson, Mark Helvey, Ron A. Heintz, Bob Hoffman, Thom Hooper, DeAnee Kirkpatrick, K. Koski, Brian Lance, Stacey Li, Marc Liverman, Matt Longenbaugh, Jon Mann, Leah Mahan, Ben Meyer, Adam Moles, Nancy Munn, Loren Peltz, Erika Phillips, Ken Phippen, Stanley Rice, Maggie Sommer, John Stadler, Dan Tonnes, and Susan Walker.

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ACRONYMS AND ABBREVIATIONS

AAPA	American Association of Port Authorities
ACZA	ammoniacal copper zinc arsenate
ADEC	Alaska Department of Environmental Conservation
ADNR	Alaska Department of Natural Resources
AFS	American Fisheries Society
Ag	silver
AI	Aleutian Islands
AMAP	Arctic Mapping and Assessment Program
As	arsenic
ATTF	Alaska Timber Task Force
BMP	best management practice
BOD	biochemical oxygen demand
BTA	best technology available
CCA	chromated copper arsenate
Cd	cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
Cr	chromium
Council	North Pacific Fishery Management Council
CSREE	Cooperative State Research, Education, and Extension
CWA	Clean Water Act
CWP	Center for Watershed Protection
dB	decibel
DDT	dichloro-diphyl-trichloroetane
DDE	dichlorodyphenyl dichloroethylene
DOI	Department of the Interior
DoN	Department of the Navy
EA	environmental assessment
EBS	Bering Sea
EFH	Essential Fish Habitat
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FC	fecal coliform (bacteria)
FERC	Federal Energy Regulatory Commission
FIFRA	Federal Institute, Fungicides, and Rodenticide Act
FL	fork length
FMC	Fishery Management Council
FREP	Futilizer Research and Education Program
FRPA	Forest Resources and Practices Act
GIS	geographical information system
GOA	Gulf of Alaska
HCB	hexachlorobenzene
HCH	hexachlorocyclohexanes
Hg	mercury

HHB	hexachlorobenzene
hz	hertz
km	kilometer
LTF	log transfer facilities
LWD	large woody debris
m	meter
mm	millimeter
MMS	Minerals Management Service
m/s^2	meters per second squared
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MARPOL	International Convention for the Prevention of Pollution from Ships
NAWQA	National Water Quality Assessment
NEPA	National Environmental Policy Act
nm	nautical mile
NMDMP	National Marine Debris Monitoring Program
NMFS	National Marine Fishery Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPPC	Northwest Power Planning Council
NRC	National Research Council
OCS	outer coastal shelf
OGTAD	Oil and Gas Technologies for the Arctic and Deep Water
OWRRI	Oregon Water Resources Research Institute
PAH	polycyclicaromatic hydrocarbons
Pb	lead
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyls
PFMC	Pacific Fishery Management Council
PNPCC	Pacific Northwest Pollution Control Council
POP	persistent organic pollutant
RPWAST	Rich Passage Wave Action Study Team
SAIC	Science Applications International Corporation
SCS	Soil Conservation Service
SPL	sound pressure levels
SSC	suspended sediment concentration
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WCS	water control structure
WDFW	Washington State Department of Fish and Wildlife
ZOD	zone of deposit

G.1 INTRODUCTION

G.1.1 Background on Essential Fish Habitat

In 1996, the U.S. Congress added new habitat conservation provisions to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), the federal law that governs U.S. marine fisheries management. The renamed Magnuson-Stevens Act mandated the identification of Essential Fish Habitat[1] (EFH) for federally managed species and consideration of measures to conserve and enhance the habitat necessary for these species to carry out their life cycles.

The Magnuson-Stevens Act requires federal agencies to consult with the National Marine Fisheries Service (NMFS) on all actions or proposed actions permitted, funded, or undertaken by the agency that may adversely affect[2] EFH. Federal agencies initiate consultation by preparing and submitting a written assessment of the effects of the proposed federal action on EFH to NMFS. If a federal action agency determines that an action will not adversely affect EFH, no consultation is required. To promote efficiency and avoid duplication, EFH consultation is usually integrated into existing environmental review procedures under other laws such as the National Environmental Policy Act (NEPA), Endangered Species Act (ESA), or Fish and Wildlife Coordination Act.

The Magnuson-Stevens Act requires NMFS to recommend conservation measures to federal and state agencies regarding actions that would adversely affect EFH. These EFH conservation recommendations are advisory, not mandatory, and may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects to EFH. Within 30 days of receiving NMFS' conservation recommendations, federal action agencies must provide a detailed response in writing. The response must include measures proposed for avoiding, mitigating, or offsetting the impact of a proposed activity on EFH. State agencies are not required to respond to EFH conservation recommendations. If a federal action agency chooses not to adopt NMFS' conservation recommendations, it must provide an explanation. Examples of federal action agencies that permit or undertake activities that may trigger EFH consultation include, but are not limited to, the U.S. Army Corps of Engineers (USACE), Environmental Protection Agency (EPA), Federal Energy Regulatory Commission (FERC), and Department of the Navy (DoN). Fishery Management Councils (FMCs) may also choose to comment on proposed actions that may adversely affect EFH.

G.1.2 Significance of Essential Fish Habitat

The waters and substrate that comprise EFH designations under the jurisdiction of the FMCs are diverse and widely distributed. They are also closely interconnected with other aquatic and terrestrial environments.

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[1] EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." "Waters" include aquatic areas and their associated physical, chemical, and biological properties. Substrate includes sediment underlying the waters. "Necessary" means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem. "Spawning, breeding, feeding, or growth to maturity" covers all habitat types utilized by a species throughout its life cycle.

[2] An adverse effect is any impact that reduces the quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species, and their habitat, as well as other ecosystem components. Adverse effects may be site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.910[a]).

The following discussion addresses non-fishing activities that may adversely affect EFH. They are grouped into four different systems in which the activities usually occur: upland, river or riverine, estuary or estuarine, and coastal or marine. Riverine systems provide important habitat that serves multiple purposes for anadromous species such as salmon. These purposes include migration, feeding, spawning, nursery, and rearing functions. Protecting these functions is key to providing for a productive system and a healthy fishery. The riparian corridor is an important component of a river system. The term "riparian" refers to the land directly adjacent to a stream, lake, or estuary. A healthy riparian area has vegetation harboring prey items (e.g., insects), contributes necessary nutrients, provides large woody debris (LWD) that creates channel structure and cover for fish, and provides shade, which controls stream temperatures (Bilby and Ward 1991). When vegetation is removed from riparian areas, waters are heated, and LWD is less common. This results in less refuge for fish, fundamental changes in channel structure (e.g., loss of pool habitats), instability of streambanks, and alteration of nutrient and prey sources within the river system (Murphy 1995, Koski 1993, Koski 1992).

Estuaries are the bays and inlets influenced by both the ocean and rivers, and they serve as the transition zone between freshwater and saltwater (Botkin et al. 1995). Estuaries support a community of plants and animals that are adapted to the zone where freshwater and saltwater mix (Zedler et al. 1992). Estuarine habitats fulfill fish and wildlife needs for reproduction, feeding, refuge, and other physiological necessities (Simenstad et al. 1991, Good 1987, Phillips 1984). Estuaries often include eelgrass beds that protect young fish from predators, provide habitat for fish and wildlife, improve water quality, and control sediments (Johnson et al. 2003, Thayer et al. 1984, Hoss and Thayer 1993, Phillips 1984). In addition, mud flats, high salt marsh, and saltmarsh creeks also provide productive shallow-water habitat for epibenthic fishes and decapods (Sogard and Able 1991).

Coastal or marine habitats comprise a variety of broad habitat types for EFH-managed species, including sand bottoms, rocky reefs, and submarine canyons. When rock reefs support kelp stands, they become exceptionally productive. Relative to other habitats, including wetlands, shallow and deep sand bottoms, and rock bottom, giant kelp habitats are substantially more productive in the fish communities they support (Bond et al. 1999). The stands provide nurseries, feeding grounds, and/or shelter to a variety of groundfish species and their prey (Feder et al. 1974, Ebeling et al. 1980).

G.1.3 Non-fishing Impacts

The diversity, widespread distribution, and ecological linkages with other aquatic and terrestrial environments make the waters and substrates that comprise EFH susceptible to a wide array of human activities unrelated to fishing.

Non-fishing activities have the potential to adversely affect the quantity or quality of EFH in riverine, estuarine, and marine systems. Broad categories of such activities include, but are not limited to, mining, dredging, fill, impoundment, discharge, water diversions, thermal additions, actions that contribute to nonpoint source pollution and sedimentation, introduction of potentially hazardous materials, introduction of exotic species, and the conversion of aquatic habitat that may eliminate, diminish, or disrupt the functions of EFH. For each activity, known and potential adverse impacts to EFH are described in this document. The descriptions explain the mechanisms or processes that may cause the adverse effects and how these may affect habitat function.

Non-fishing activities discussed in this document are subject to a variety of regulations and restrictions designed to limit environmental impacts under federal, state, and local laws. For example, laws and regulations pertaining to oil and gas exploration, development production and transportation can be found in such documents as the Northeast National Petroleum Reserve - Alaska Final Integrated Activity Plan/Environmental Impact Statement (Department of the Interior [DOI] 1998), Cook Inlet Areawide

1999 Oil and Gas Lease Sale, final Finding of the Director (Alaska Department of Natural Resources [ADNR] 1999), and the Cook Inlet Planning Area Oil and Gas Lease Sales 191 and 199 (Minerals Management Service [MMS] 2003). Many current requirements help to avoid or minimize adverse effects to aquatic habitats, including EFH. The conservation recommendations contained in this document are rather general and may overlap with certain existing standards for specific development activities. Nevertheless, the recommendations highlight practices that can help to avoid and minimize adverse effects to EFH. During EFH consultations between NMFS and other agencies, NMFS strives to provide reasonable and scientifically based recommendations that account for restrictions imposed under various state and federal laws by agencies with appropriate regulatory jurisdiction. Listing all applicable environmental laws and management practices herein is beyond the scope of the document. Moreover, the coordination and consultation required by Section 305(b) of the Magnuson-Stevens Act do not supersede the regulations, rights, interests, or jurisdictions of other federal or state agencies. NMFS will not recommend that state or federal agencies take actions beyond their statutory authority, and NMFS' EFH conservation recommendations are not binding.

The conservation measures discussed in this document should be viewed as options to avoid, minimize, or compensate for adverse impacts and promote the conservation and enhancement of EFH. Ideally, non-water-dependent actions should not be located in EFH if such actions may have adverse impacts on EFH. Activities that may result in significant adverse effects on EFH should be avoided where less environmentally harmful alternatives are available. If there are no alternatives, the impacts of these actions should be minimized. Environmentally sound engineering and management practices should be employed for all actions that may adversely affect EFH. If avoidance or minimization is not practicable, or will not adequately protect EFH, compensatory mitigation (as defined for Section 404 of the Clean Water Act – the restoration, creation, enhancement, or in exceptional circumstances, preservation of wetlands and/or other aquatic resources for the purpose of compensating for unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved) should be considered to conserve and enhance EFH.

G.1.4 Purpose of the Document

Section 303(a)(7) of the Magnuson-Stevens Act requires FMPs to identify activities other than fishing that may adversely affect EFH and define actions to encourage the conservation and enhancement of EFH, including recommended options to avoid, minimize, or compensate for the adverse effects identified. During consultation, agencies strive to consider all potential non-fishing impacts to EFH so that the appropriate mix of recommendations can be made. Because impacts that may adversely affect EFH can be direct, indirect, and cumulative, the biologist must consider and analyze these interrelated impacts. Consequently, it is not unusual for particular impacts to be overlooked or discounted during a consultation. In addition to fulfilling the requirements for revising the FMPs, this document will be useful to NMFS biologists reviewing proposed projects as they consider potential impacts that may adversely affect EFH.. The document should also be useful for federal action agencies undertaking EFH consultations, especially in preparing EFH assessments.

The conservation recommendations included with each activity present a series of site-specific measures the action agency can undertake to avoid, offset, or mitigate impacts to EFH. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect EFH. More specific or different measures based on the best and most current scientific information may be developed before or during EFH consultations and communicated to the appropriate agency. The conservation recommendations provided herein represent a short menu of actions that can contribute to the conservation, enhancement, and proper functioning of EFH.

G.1.5 Overall Approach and Comparison to Previous Analyses

The 1999 EFH Environmental Assessment (EA) limited the scope of the discussion of non-fishing threats to coastal activities with some references to possible offshore impacts from non-fishing activities. The EFH EA categorized the non-fishing impacts to EFH in Alaska by combining several types of activities that may or may not occur together and calling out specific activities that cause habitat alteration. For example, the EFH EA combined dredging, fill, and excavation, providing a unified narrative discussion and analysis of these activities as they relate to port construction and support activities. These activities often occur independently, and the possible impacts to EFH that may occur from one activity (e.g., dredging) differ from those that may associated with another (e.g., fill). In contrast, the EFH EA's discussion and analysis of possible adverse impacts from certain activities (e.g., mining) were limited to activities that occur in the marine environment without addressing the same activities in other areas with potential adverse effects on EFH (such as anadromous streams).

The format for discussion of non-fishing threats in the 1999 EFH EA summarized potential impacts from each activity and then provided an expanded discussion with general conservation recommendations for some of the activities. In addition, an attached worksheet provided a professional interpretative summary of the broad category of threats discussed in the Non-fishing Adverse Impacts section. Habitat conservation and enhancement recommendations were provided in tabular format, starting with a broad category of habitats (i.e., near shore habitat and waters [0 to 3 nautical miles (nm)], pelagic habitat and waters [3 to 12 nm], and offshore habitat and waters [more than12 nm]) with general recommendations as they relate to a particular area or habitat type and associated managed species.

Impacts to EFH can be direct, indirect, and cumulative. While it is necessary to distinguish between activities to identify possible adverse impacts, it is equally important to consider and analyze these activities as they interrelate within habitats. Appendix G to the EFH EIS, therefore, takes an ecosystem perspective and provides more detail and a different format than the non-fishing impacts section of the 1999 EFH EA.

This document is organized by activities that may potentially impact EFH occurring in four discrete ecosystems. The separation of these ecosystems is artificial, and many of the impacts and their related activities are not exclusive to one system. For instance, as recognized in the discussion of the 1999 EFH EA, activities such as sand and gravel mining occur in riverine, estuarine, and marine systems. Because activities are discussed in the section corresponding to the primary ecosystem where they occur, readers should use the Master Index at the end of the document to identify other systems where such activities may also take place. Also, certain activities (e.g., pile driving) have specific potential impacts to EFH and may be associated with other construction activities (e.g., dredging) that have their own potential impacts. Readers should use the Master Index to ensure that all activities for a given project are considered.

Similar to the Non-fishing Adverse Impacts section of the 1999 EFH EA, this document is not meant to provide an exhaustive review. This document is, however, a result of a collaborative effort among the NMFS Alaska Region, Northwest Region, and Southwest Region and the respective Fisheries Science Centers, which provided a broader range of expertise to reach consensus regarding the general conservation recommendations.

The format for presenting the information in this document provides an introductory description of each activity, identification of potential adverse impacts, and suggested general conservation measures that would help minimize and avoid adverse effects of non-fishing activities on EFH. Table 3.4-36 of the EIS identifies the categories from Appendix G and correlates them with possible changes in physical, chemical, and biological parameters, and Table 3.4-37 takes the same categories from Appendix G and broadly interprets whether the effects from the activities in Alaska have been positive, insignificant, negative, or unknown.

G.2 UPLAND ACTIVITIES

G.2.1 Nonpoint Source Pollution

The information in this section is adapted from EPA 1993.

Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, seepage, or hydrologic modification. Technically, the term nonpoint source means anything that does not meet the legal definition of point source in Section 502(14) of the Clean Water Act (CWA), which refers to discernable, confined, and discrete conveyance from which pollutants are or may be discharged. The major categories of nonpoint pollution are as follows:

- Agricultural runoff
- Urban runoff, including developed and developing areas (Section G.2.2)
- Silvicultural (forestry) runoff (Section G.2.1.1)
- Marinas and recreational boating
- Road construction
- Channel and streambank modifications, including channelization (Section G.4.7)
- Streambank and shoreline erosion

Nonpoint source pollution is usually lower in intensity than an acute point source event, but it may be more damaging to fish habitat in the long term. Nonpoint source pollution is often difficult to detect. It may affect sensitive life stages and processes, and the impacts may go unnoticed for a long time. When severe population impacts are finally noticed, they may not be tied to any one event; hence, it may be difficult to correct, clean up, or mediate.

G.2.1.1 Silviculture/Timber Harvest

Recent revisions of Alaska's federal and state timber harvest regulations and best management practices (BMPs) have resulted in increased protection of EFH on federal, state, and private timber lands (Tongass Land Management Plan, http://www.fs.fed.us/r10/tongass/management%20news/tlmp/tlmp.shtml; Chugach Land and Resources Management Plan, http://www.geographynetwork.com/chugach/; and the Alaska Forest Resources and Practices Act [FRPA], AS 41.17 (Murphy and Koski 1991). The Tongass and Chugach forest management plans provide for multiple uses of national forest lands and are highly protective of EFH on lands designated for timber production and on less intensively managed lands. The FPRA and its regulations set riparian buffers and establish mandatory BMPs for timber harvesting, road construction, road maintenance, and reforestation to protect water quality on state and privately owned timber production lands. The FPRA is also the standard for compliance with federal Coastal Zone Management Act and Clean Water Act requirements in Alaska.

Current forest management practices, when fully implemented and effective, avoid or minimize adverse effects to EFH that can result from the harvest and cultivation of timber and other forestry products. However, timber harvest can have both short- and long-term impacts throughout many coastal watersheds and estuaries if management practices are not fully implemented or effective. Past timber harvest in Alaska was not conducted under the current protective standards, and some effects from past harvesting continue to affect EFH.

In general, timber harvest can have a variety of effects such as removing the dominant vegetation; converting mature and old-growth upland and riparian forests to tree stands or forests of early seral stage; reducing permeability of soils and increasing the area of impervious surfaces; increasing sedimentation from surface runoff and mass wasting processes; altering hydrologic regimes; and impairing fish passage through inadequate design, construction, and/or maintenance of stream crossings (Northcote and Hartman 2004). As noted above, effects on EFH can be avoided or minimized by adhering to modern forestry practices.

If appropriate environmental standards are not followed, forest conditions after harvest may result in altered or impaired instream habitat structure and watershed function. Timber harvest may result in inadequate or excessive surface and stream flows, increased streambank and streambed erosion, loss of complex instream habitats, sedimentation of riparian habitat, and increased surface runoff with associated contaminants (e.g., herbicides, fertilizers, and fine sediments). Hydrologic characteristics (e.g., water temperature), annual hydrograph change, and greater variation in stream discharge can be associated with timber harvest. Alterations in the supply of LWD and sediment can have negative effects on the formation and persistence of instream habitat features. Excess debris in the form of small pieces of wood and silt can cover benthic habitat and reduce dissolved oxygen levels.

G.2.1.1.1 Potential Adverse Impacts

There are many complex and important interactions, in both small and large watersheds, between fish and forests (Northcote and Hartman, 2004). Five major categories of activities can adversely affect EFH: 1) construction of logging roads, 2) creation of fish migration barriers, 3) removal of streamside vegetation, 4) hydrologic changes and sedimentation and 5) disturbance associated with log transfer facilities (LTFs) (Section G.4.9). Potential impacts to EFH have been greatly reduced by the adoption of BMPs designed to protect fish habitat.

Improperly engineered, constructed, or maintained logging roads can destabilize slopes and increase erosion and sedimentation (Section G.2.3). Two major types of erosion occur: mass wasting and surface erosion. Mass movement of soils, commonly referred to as landslides or debris slides, can occur with timber harvest and road building on high-hazard soils and unstable slopes. Both the frequency and size of debris slides can be increased when logging roads are built on, or timber is harvested from, these unstable land forms. Increased erosion can occur, and some sediment deposition can reach downslope waterways. Erosion from roadways is most severe when construction practices do not include properly located, sized, and installed culverts, proper ditching, and ditch blocker water bars (Furniss et al. 1991). Under current federal and state BMPs, hazardous slopes must be avoided or site specific hazard management plans must be developed.

Stream crossings (bridges and culverts) on forest roads can be inadequately designed, installed, and maintained, and they frequently result in full or partial barriers to both upstream and downsteam fish migration. For example, between 13 and 17 percent of the culverts installed since 1997 on the Tongass National Forest do not meet fish passage standards, although most failures are for the upstream migration of juveniles during high-flow events (Tongass Best Management Practices Implementation Monitoring Report, 2003). Perched and undersized culverts can accelerate stream flows so that these structures become velocity barriers for migrating fish. However, perched culverts are prohibited under current BMPs and all culverts are now subject to sizing requirements designed to allow passage of fish and significant flood events.

Blocked culverts result from undersized designs or inadequate maintenance to remove debris. Blocked culverts can result in displacement of the stream from the downstream channel to the roadway or roadside ditch, resulting in dewatering of the downstream channel and increased erosion of the roadway. Under modern BMPs, however, culverts must be properly sized and maintained.

Culverts and bridges deteriorate structurally over time. Failure to replace or remove them at the end of their useful life may cause partial or total fish passage blockage. Current BMPs require removal of culverts upon road closure unless other measures are warranted. Caution should be used when removing culverts. Channel incision can often occur downstream of a culvert and generally moves upstream. An existing culvert can act as a grade control, halting the upstream progression of a headcut and causing further channel regrade (Castro 2003). The unchecked upstream progression of a headcut can cause further damage to EFH. Additional information on culverts is available in the August 2001 Alaska Department of Fish and Game and Alaska Department of Transportation and Public Facilities Memorandum of Agreement for the Design, Permitting, and Construction of Culverts for Fish Passage, http://www.sf.adg.state.ak.us/SARR/fishpassage/pdfs/dot_adfg_fishpass080301.pdf.

Removing streamside vegetation increases the amount of solar radiation reaching the stream and can result in warmer water temperatures, especially in small, shallow streams of low velocity. In southeast Alaska, Meehan et al. (1969) found that maximum temperature in logged streams without riparian buffers exceeded that of unlogged streams by up to 2.3°C, but did not reach lethal temperatures. In cold climates, the removal of riparian vegetation can result in lower water temperatures during winter, increasing the formation of ice and damaging and delaying the development of incubating fish eggs and alevins. Current BMPs require retention of riparian buffers for shade, which should limit changes in water temperature and dissolved oxygen (Shult and McGreer 2001).

By removing vegetation, timber harvest reduces transpiration losses from the landscape and decreases the absorptive capability of the groundcover. These changes can result in increased surface runoff during periods of high precipitation and decreased base flows during dry periods (Heifetz et al. 1996, Myren and Ellis 1984). Reduced soil strength can result in destabilized slopes and increased sediment and debris input to streams (Swanston 1974). Sediment deposition in streams can reduce benthic community production (Culp and Davies 1983), cause mortality of incubating salmon eggs and alevins (Koski 1981), and reduce the amount of habitat available for juvenile salmon (Heifetz et al. 1996). Cumulative sedimentation from logging activities can significantly reduce the egg-to-fry survival of coho and chum salmon (Cederholm and Reid 1987). Reductions in the supply of LWD also result when old-growth forests are removed, with resulting loss of habitat complexity that is critically important for successful salmonid spawning and rearing (Bisson et al. 1988, Murphy and Koski 1989). Current riparian buffer standards and BMPs are being implemented in most instances (Tongass National Forest Draft Annual Monitoring Report 2003) and long-term effectiveness studies are being conducted to determine if timber harvest has any effect on habitat condition (Martin and Grotefelt, 2001; Martin and Shelly 2004).

G.2.1.1.2 Recommended Conservation Measures

1. Avoid timber operations to the extent practicable near streams with EFH. For the Alaska region, see the following links: Fish: Forest-Wide Standards and Guides:
   - http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF
   - http://www.or.blm.gov/ForestPlan/newsandga.pdf
   - http://www.dnr.state.ak.us/forestry/pdfs/forpracregs.pdf.
2. Avoid timber operations to the extent practicable in wetlands contiguous with anadromous fish streams. See the following links: Wetlands: Forest-Wide Standards and Guides:
   - http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF
   - http://www.dnr.state.ak.us/forestry/pdfs/forpracregs.pdf.

3. Avoid timber operations to the extent practicable near estuary and beach habitats. See the following links: Beach and Estuary Fringe: Forest-Wide Standards and Guides:
   - http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF
   - http://www.fs.fed.us/r10/chugach/forest_plan/forest_plan_web.pdf.
4. Maintain riparian buffers along all streams to the extent practicable. In Alaska, buffer width is site-specific and dependent on use by anadromous and resident fish and stream process type. Stream process groups are described in the following link:
   - http://www.fs.fed.us/r10/TLMP/F_PLAN/APPEND_D.PDF

   Standards and guidelines for riparian buffers for Alaska are described in the following links. Riparian Forest-Wide Standards and Guides:
   - http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF
   - http://www.fs.fed.us/r10/chugach/forest_plan/forest_plan_web.pdf FPRA

   Riparian buffer regulations can be found at:
   - http://www.dnr.state.ak.us/forestry/pdfs/fprachrt.pdf.
5. Incorporate watershed analysis into timber and silviculture projects whenever possible or practicable. Particular attention should be given to the cumulative effects of past, present, and future timber sales within the watershed. See the following link on watershed analysis:
   - http://www.fs.fed.us/r10/TLMP/F_PLAN/APPEND_J.PDF.
6. For forest roads, see Section G.2.3, Road Building and Maintenance. Also see the following links: Transportation: forest-wide standards and guides:
   - http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF

   Soils and water: forest-wide standards and guides:
   - http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF
   - http://www.fs.fed.us/r10/chugach/forest_plan/forest_plan_web.pdf
   - http://www.dnr.state.ak.us/forestry/pdfs/forpracregs.pdf.

G.2.1.2 Pesticide Application (includes insecticides, herbicides, fungicides)

Pesticides are substances intended to prevent, destroy, control, repel, or mitigate any pest. They include the following: insecticides, herbicides, fungicides, rodenticides, repellents, bactericides, sanitizers, disinfectants, and growth regulators. More than 800 different pesticides are currently registered for use in the U.S. Legal mandates covering pesticides are the CWA and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Water quality criteria for the protection of aquatic life have only been developed for a few of the currently used chemicals (EPA, Office of Pesticide Programs). In Alaska, the pesticide control program is administered by the Alaska Department of Environmental Conservation's (ADEC's) Division of Environmental Health (http://www.state.ak.us/dec/eh/pest/index.htm). Collectively, these substances are designed to repel, kill, or regulate the growth of undesirable biological organisms. This diverse group includes fungicides, herbicides, insecticides, nematicides, molluscicides, rodenticides, fumigants, disinfectants, repellents, wood preservatives, and antifoulants. The most common pesticides are insecticides, herbicides, and fungicides. These are used for pest control on forested lands, agricultural crops, tree farms and nurseries, highways and utility rights of way, parks and golf courses, and residences. Pesticides can enter the aquatic environment as single chemicals or as complex mixtures. Direct applications, surface runoff, spray drift, agricultural return flows, and groundwater intrusions are all examples of transport processes that deliver pesticides to aquatic ecosystems.

Pesticides are frequently detected in freshwater and estuarine systems that provide EFH. Nationwide, the most comprehensive environmental monitoring efforts have been conducted by the U.S. Geological Survey (USGS) as part of the National Water Quality Assessment (NAWQA) Program. A variety of human activities, such as fire suppression on forested lands, forest site preparation, noxious weed control, right-of-way maintenance (roads, railroads, power lines, etc.), algae control in lakes and irrigation canals, various agricultural practices, riparian habitat restoration, and urban and residential pest control result in contamination from these substances. The term "pesticide" is a collective description of hundreds of chemicals with different sources, different fates in the aquatic environment, and different toxic effects on fish and other aquatic organisms. Despite these variations, all current use pesticides are (1) specifically designed to kill, repel, or regulate the growth of biological organisms, and (2) intentionally released into the environment. Habitat alteration from pesticides is different from more conventional water quality parameters, such as temperature, suspended solids, or dissolved oxygen, because, unlike temperature or dissolved oxygen, the presence of pesticides can be difficult to detect due to limitations in proven methodologies. This monitoring may also be expensive. As analytical methodologies have improved in recent years, however, the number of pesticides documented in fish and their habitats has increased.

G.2.1.2.1 Potential Adverse Impacts

There are three basic ways that pesticides can adversely affect EFH. These are (1) a direct toxicological impact on the health or performance of exposed fish, (2) an indirect impairment of the productivity of aquatic ecosystems, and (3) a loss of aquatic vegetation that provides physical shelter for fish.

Fish kills are rare when pesticides are used according to their labels. For fish, most effects from pesticide exposures are sublethal. Sublethal effects are a concern if they impair the physiological or behavioral performance of individual animals in ways that will decrease their growth or survival, alter migratory behavior, or reduce reproductive success. In addition to early development and growth, key physiological systems affected include the endocrine, immune, nervous, and reproductive systems. Many pesticides have been shown to impair one or more of these physiological processes in fish (Moore and Waring 2001). In general, however, the sublethal impacts of pesticides on fish health are poorly understood. Accordingly, this is a focus of recent and ongoing NOAA research (Scholz et al. 2000, Van Dolah et al. 1997).

The effects of pesticides on ecosystem structure and function can be key factors in determining the cascading impacts of those chemicals on fish and other aquatic organisms at higher trophic levels (Preston 2002). This includes impacts on primary producers (Hoagland et al. 1996) and aquatic microorganisms (DeLorenzo et al. 2001), as well as on macroinvertebrates that are prey species for fish. For example, many pesticides are specifically designed to kill insects. Not surprisingly, these chemicals are relatively toxic to insects and crustaceans that inhabit river systems and estuaries. Overall, pesticides will have an adverse impact on fish habitat if they reduce the productivity of aquatic ecosystems. Finally, some herbicides are toxic to aquatic plants that provide shelter for various fish species. A loss of aquatic vegetation could damage nursery habitat or other sensitive habitats, such as eelgrass beds and emergent marshes.

G.2.1.2.2 Recommended Conservation Measures

The recommended conservation measures for pesticide application include the following:

1. Incorporate integrated pest management and BMPs as part of the authorization or permitting process to ensure the reduction of pesticide contamination in EFH (Scott et al. 1999).
2. Carefully review labels and ensure that application is consistent. Follow local, supplemental instructions such as state-use bulletins where they are available.
3. Avoid the use of pesticides in and near EFH. ADEC has established a pesticide-free area of 35 feet (10.67 meters) from any surface or marine water body and a protective area in which pesticides will not be applied that would extend beyond the pesticide-free area to ensure that no pesticides enter the pesticide-free area. Protective areas will be different for each project. ADEC considers region,

terrain, weather, droplet size, pesticide labeling directions, and other conditions to decide how far the protective area must extend to ensure that no pesticides end up in the pesticide-free area.
4. Refrain from aerial spraying of pesticides on windy days.

G.2.2 Urban/Suburban Development

The information in this section is adapted from NMFS 1998, a, b.

Urban development is most likely the greatest non-fishing threat to EFH. Urban growth and development in the U.S. continue to expand in coastal areas at a rate approximately four times greater than in other areas. Urban and suburban development and the corresponding infrastructure result in four broad categories of impacts to aquatic ecosystems: hydrological, physical, water quality, and biological indicators (Center for Watershed Protection [CWP] 2003). Runoff from impervious surfaces is the most widespread source of pollution into the nation's waterways (EPA 1995). When a watershed's impervious cover exceeds 10 percent, impacts to stream quality can be expected (CWP 2003).

G.2.2.1 Potential Adverse Impacts

Development activities within watersheds and in coastal marine areas often impact the EFH of managed species on both long- and short-term scales. The CWP made a comprehensive review of the impacts associated with impervious cover and urban development and found a negative relationship between watershed development and about 26 stream quality indicators (CWP 2003). Many of the impacts listed here are discussed in greater detail in other sections of this document. The primary impacts include (1) the loss of riparian and shoreline habitat and vegetation and (2) runoff. Upland and shoreline vegetation removal can increase stream water temperatures, reduce supplies of LWD, and reduce sources of prey and nutrients to the water system. An increase in impervious surfaces, such as the addition of new roads (see Section G.2.3), roofs, bridges, and parking facilities, results in a decreased infiltration to groundwater and increased runoff volumes. This also has the potential to adversely affect water quality and water quantity/timing in downstream water bodies (i.e., estuaries and coastal waters).

Salmonids and other anadromous fish appear to be particularly impacted by the amount of impervious cover in a watershed (CWP 2003). In a study in the Pacific Northwest, sensitive coho salmon were seldom found in watersheds above 10 or 15 percent impervious cover (Luchetti and Feurstenburg 1993). Key stressors in urban streams, such as higher peak flows and reduction in habitat complexity (e.g., fewer pools, LWD, and hiding places), as well as changes in water quality, are believed to change salmon species composition, favoring cutthroat trout populations over the natural coho populations (Horner et al. 1999 and May et al. 1997). In the mid-Atlantic region, native trout are temperature-sensitive and are seldom present in watersheds where impervious cover exceeds 15 percent (Schueler 1994).

The loss of riparian and shoreline habitat and vegetation can increase water temperatures and remove sources of cover. Such impacts can alter the structure of benthic and fish communities, resulting in a reduction in diversity and abundance of EFH species. Shoreline stabilization projects (Section G.4.7) that alter reflective wave energy can impede or accelerate natural movements of shoreline substrates, thereby affecting intertidal and sub-tidal habitats. Channelization of rivers causes loss of floodplain connectivity and simplification of habitat. The resulting sediment runoff can also restrict tidal flows and elevations, resulting in losses of important fauna and flora (e.g., submerged aquatic vegetation).

Due to the intermittent nature of rainfall and runoff, the large variety of pollutant source types, and the variable nature of source loadings, urban runoff is difficult to control (Safavi 1996). The National Water Quality Inventory (EPA 2002) reports that runoff from urban areas is the leading source of impairment to surveyed estuaries and the third largest source of impairment to surveyed lakes. Such runoff includes construction sediments, oil from autos, bacteria from failing septic systems, road salts, and heavy metals. Urban areas have an insidious pollution potential that one-time events such as oil spills do not. Pollutant increases result in gradual declines in habitat quality.

Storm drains are often built to move water quickly away from roads, resulting in increased water input to streams. The greater volume and velocity erode streambanks, increasing sediment loads and often changing temperatures. In a simulation model comparing an urban watershed with a forested watershed, Corbett et al. (1997) demonstrated that urban runoff volume and sediment yield were 5.5 times greater than forest runoff.

Among contaminants that can enter watersheds, polycyclic aromatic hydrocarbons (PAH) are among the most toxic to aquatic life and can persist for decades (Short et al. 2003). Waterborne PAH levels are often significantly higher in urbanized than non-urbanized watersheds (Fulton et al. 1993). Petroleum-based contaminants contain PAHs, which when released into the environment through spill, combustion and atmospheric deposition can cause acute toxicity to managed species and their prey, as some PAHs are known carcinogens and mutagens (Neff 1985).

Failing septic systems are an outgrowth of urban development. EPA estimates that 10 to 25 percent of all individual septic systems are failing at any one time, introducing excrement, detergents, chlorine and other chemicals into the environment. Even treated wastewater from urban areas can alter the physiology of intertidal organisms (Moles, A. and N. Hale 2003). Sewage discharge is a major source of coastal pollution, contributing 41, 16, 41, and 6 percent of the total pollutant load for nutrients, bacteria, oils, and toxic metals, respectively (Kennish 1998). Nutrients such as phosphorus concentrations, in particular, are indicative of urban stormwater runoff (Holler 1990). Sewage wastes may also contain significant amounts of organic matter that exert a biochemical oxygen demand (Kennish 1998). Organic contamination contained within urban runoff can also cause immuno suppression (Arkoosh et al. 2001, NMFS Draft 1998).

G.2.2.2 Recommended Conservation Measures

The recommended conservation measures for urban/suburban development are provided below. For additional measures, see Section G.2.3.2, Recommended Conservation Measures.

1. Implement BMPs (EPA 1993) for sediment control during construction and maintenance operations. These can include avoiding ground-disturbing activities during the wet season; minimizing exposure time of disturbed lands; using erosion prevention and sediment control methods; minimizing the spatial extent of vegetation disturbance; maintaining buffers of vegetation around wetlands, streams, and drainage ways; and avoiding building activities in areas with steep slopes and areas prone to mass wasting events with highly erodible soils. Use methods such as sediment ponds, sediment traps, bioswales, or other facilities designed to slow water runoff and trap sediment and nutrients.
2. Avoid using hard engineering structures for shoreline stabilization and channelization when possible. Use bioengineering approaches (i.e., applying vegetation approaches with principles of geomorphology, ecology, and hydrology) to protect shorelines and riverbanks. Naturally stable shorelines and river banks should not be altered (Section G.4.7).
3. Encourage comprehensive planning for watershed protection to avoid filling and building in floodplain areas affecting EFH. Development sites should be planned to minimize clearing and grading, cut-and-fill, and new impervious surfaces.
4. Where feasible, remove impervious surfaces such as abandoned parking lots and buildings from riparian and shoreline areas, and reestablish wetlands and native vegetation.
5. Protect and restore vegetated buffer zones of appropriate width along all streams, lakes, and wetlands that include or influence EFH.

6. Manage stormwater to duplicate the natural hydrologic cycle, maintaining natural infiltration and runoff rates to the maximum extent practicable.
7. Where in-stream flows are insufficient to maintain water quality and quantity needed for EFH, establish conservation guidelines for water use permits and encourage the purchase or lease of water rights and the use of water to conserve or augment instream flows in accordance with state and federal water laws.
8. Encourage municipalities to use the best available technologies in upgrading their wastewater systems to avoid combined sewer overflow problems and chlorinated sewage discharges into rivers, estuaries, and the ocean.
9. Design and install proper on-site disposal systems. Locate them away from open waters, wetlands, and floodplains.

G.2.3 Road Building and Maintenance

The building and maintenance of roads can affect aquatic habitats by increasing rates of natural processes such as debris slides or landslides and sedimentation, introducing exotic species, degrading water quality, and introducing chemical contamination (e.g., petroleum-based contaminants; Section G.2.2). Paved and dirt roads introduce an impervious or semipervious surface into the landscape. This surface intercepts rain and creates runoff, carrying soil, sand and other sediments, and oil-based materials quickly downslope. If roads are built near streams, wetlands, or other sensitive areas, they may experience increased sedimentation that occurs from maintenance and use, as well as during storm and snowmelt events. Even carefully designed and constructed roads can become sources of sediment and pollutants if they are not properly maintained.

G.2.3.1 Potential Adverse Impacts

The effects of roads on aquatic habitat can be profound. They include (1) increased deposition of fine sediments, (2) changes in water temperature, (3) elimination or introduction of migration barriers such as culverts, (4) changes in streamflow, (5) introduction of non-native plant species, and (6) changes in channel configuration (see Section G.2.1.1 and the standards referenced).

Poorly surfaced roads can substantially increase surface erosion. The rate of erosion is primarily a function of storm intensity, surfacing material, road slope, and traffic levels. This surface erosion results in an increase in fine sediment deposition (Cederholm and Reid 1987, Bilby et al. 1989, MacDonald et al. 2001, Ziegler et al. 2001). Increased fine-sediment deposition in stream gravels has been linked to decreased fry emergence and juvenile densities, loss of winter carrying capacity, and increased predation of fishes. Increased fines can reduce benthic production or alter the composition of the benthic community. For example, embryo-to-emergent fry survival of incubating salmonids is negatively affected by increases in fine sediments in spawning gravels (Chapman 1988, Everest et al. 1987, Koski 1981, Scrivener and Brownlee 1989, Weaver and Fraley 1993, Young et al. 1991).

Roads built adjacent to streams can result in changes in water temperature and increased sunlight reaching the stream if riparian vegetation is removed and/or altered in composition. Beschta et al. (1987) and Hicks et al. (1991) document some of the negative effects of road construction on fish habitat, including elevation of stream temperatures beyond the range of preferred rearing where vegetation has been removed, inhibition of upstream migrations, increased disease susceptibility, reduced metabolic efficiency, and shifts in species assemblages.

Roads can also degrade aquatic habitat through improperly placed culverts at road-stream crossings that reduce or eliminate fish passage (Belford and Gould 1989, Clancy and Reichmuth 1990, Evans and Johnston 1980, Furniss et al. 1991). In a large river basin in Washington, 13 percent of the historical coho habitat was lost due to improper culvert design and placement (Beechie et al. 1994). Road crossings also affect benthic communities of stream invertebrates. Roads have a negative effect on the biotic integrity of both terrestrial and aquatic ecosystems (Trombulak and Frissell 2000). Studies indicate that populations of non-insect invertebrates tend to increase the farther away they are from a road (Luce and Crowe 2001).

Roads may be the first point of entry into a virgin landscape for non-native grass species that are seeded along road cuts or introduced from seeds transported by tires and shoes. Roads can serve as corridors for such species, allowing plants to move further into the landscape (Greenberg et al. 1997, Lonsdale and Lane 1994). Some non-native plants may be able to move away from the roadside and into aquatic sites of suitable habitat, where they may out-compete native species and have significant biological and ecological effects on the structure and function of the ecosystem.

Roads have three primary effects on hydrologic processes. First, they intercept rainfall directly on the road surface, in road cutbanks, and as subsurface water moving down the hillslope. Second, they concentrate flow, either on the road surfaces or in adjacent ditches or channels. Last, they divert or reroute water from flowpaths that would otherwise be taken if the road were not present (Furniss et al. 1991).

Road drainage and transport of water and debris, especially during heavy rains and snow melt periods, are primary reasons why roads fail, often with major structural, ecological, economic, or other social consequences. The effects of roads on peak streamflow depend on the size of the watershed and the density of roads. Two of the effects are (1) changes in flood flows (Wemple et al. 1996), mainly in smaller basins and for smaller floods (Beschta et al. 2000), and (2) increases in channel erosion and mass wasting (Montgomery 1994, Madej 2001, Wemple et al. 2001). For example, capture and rerouting of water can dewater one small stream and cause major channel adjustments in the stream receiving the additional water. In large watersheds with low road density, properly located and maintained roads may constitute a small proportion of the land surface and have relatively insignificant effects on peak flow.

Roads can lead to increased rates of natural processes such as debris or landslides and sedimentation when slopes are destabilized and surface erosion and soil mass movement increases. Erosion is most severe when poor construction practices are allowed, combined with inadequate attention to proper road drainage and maintenance practices. Mass movement risks increase when roads are constructed on high-hazard soils and overly steep slopes. In steep areas prone to landslides, rates of mass soil movements affected by roads include shallow debris slides, deep-seated slumps and earthflows, and debris flows. Accelerated erosion rates from roads because of debris slides range from 30 to 300 times the natural rate in forested areas, but vary with terrain in the Pacific Northwest (Sidle et al. 1985). The magnitude of road-related mass erosion varies by climate, geology, road age, construction practices, and storm history. Road-related mass failures can result from various causes, including improper placement and construction of road fills and stream crossings; inadequate culvert sizes to pass water, sediment, and wood during floods; poor road siting; modification of surface or subsurface drainage by the road surface or prism; and diversion of water into unstable parts of the landscape (Burroughs et al. 1976, Clayton 1983, Hammond et al. 1988, Furniss et al. 1991, Larsen and Parks 1997).

G.2.3.2 Recommended Conservation Measures

The following conservation measures for road building and maintenance should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. To the extent practicable, avoid locating roads near fish-bearing streams. Roads should be sited to avoid sensitive areas such as streams, wetlands, and steep slopes.
2. Incorporate appropriate erosion control and stabilization measures into road construction plans to reduce erosion potential.
3. Build bridges when possible. If culverts are to be used, they should be sized, constructed, and maintained to match the gradient and width of the stream, so as to accommodate design flood flows, and they should be large enough to provide for migratory passage of adult and juvenile fishes. If appropriate, consider using the culvert guidelines contained in the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities Fish Pass Memorandum of Agreement, August, 2001 (http://www.sf.adg.state.ak.us/SARR/fishpassage/pdfs/dot_adfg_fishpass080301.pdf).
4. Locate stream crossings in stable stream reaches.
5. Design bridge abutments to minimize disturbances to streambanks and place abutments outside of the floodplain whenever possible.
6. To the extent practicable, avoid road construction across alluvial floodplains, mass wastage areas, or braided stream bottom lands unless site-specific protection can be implemented to ensure protection of soils, water, and associated resources.
7. Avoid side-casting of road construction and maintenance materials on native surfaces and into streams.
8. To the extent practicable, use native vegetation in stabilization plantings.
9. Ensure that maintenance operations avoid adverse affects to EFH.

G.3 RIVERINE ACTIVITIES

G.3.1 Mining

Mining and mineral extraction activities take many forms, such as commercial dredging and recreational suction dredging, placer, area surface removal, and contour operations (Section G.5.6). Activities include gravel mining (NMFS 2004), exploration, site preparation, mining, milling, waste management, decommissioning or reclamation, and mine abandonment (American Fisheries Society [AFS] 2000). Mining and its associated activities have the potential to cause environmental impacts from exploration through post-closure. These impacts may include adverse effects to EFH. The operation of metal, coal, rock quarries, and gravel pit mining has caused varying degrees of environmental damage in urban, suburban, and rural areas. Some of the most severe damage, however, occurs in remote areas, where some of the most productive fish habitat is often located (Sengupta 1993). In Alaska, existing regulations, promulgated and enforced by other federal and state agencies, have been designed to control and manage these changes to the landscape to avoid and minimize impacts. These regulations are regularly updated as new technologies are developed to improve mineral extraction, reclaim mined lands, and limit environmental impacts. However, while environmental regulations may avoid, limit, control, or offset many of these potential impacts, mining will, to some degree, always alter landscapes and environmental resources (National Research Council [NRC] 1999).

G.3.1.1 Mineral Mining

G.3.1.1.1 Potential Adverse Impacts

Potential impacts from mining include (1) adverse modification of hydrologic conditions so as to cause erosion of desirable habitats, (2) removal of substrates that serve as habitat for fish and invertebrates, (3) conversion of habitats,(4) release of harmful or toxic materials, and (5) creation of harmful turbidity levels.

The effects of mineral mining on EFH depend on the type, extent, and location of the activities. Minerals are extracted using several methods. Surface mining involves suction dredging, hydraulic mining, panning, sluicing, strip mining, and open-pit mining (including heap leach mining). Underground mining uses tunnels or shafts to extract minerals by physical or chemical means. Surface mining probably has a greater potential to affect aquatic ecosystems, though specific effects will depend on the extraction and processing methods and the degree of disturbance (Spence et al. 1996). Surface mining has the potential to eliminate vegetation, permanently alter topography, permanently and drastically alter soil and subsurface geological structure, and disrupt surface and subsurface hydrologic regimes (AFS 2000). While mining may not be as geographically pervasive as other sediment-producing activities, surface mining typically increases sediment delivery much more per unit of disturbed area than other activities because of the level of disruption of soils, topography, and vegetation. (Nelson et al. 1991).

Mining and placement of spoils in riparian areas can cause the loss of riparian vegetation and changes in heat exchange, leading to higher summer temperatures and lower winter stream temperatures (Spence et al. 1996). Bank instability can also lead to altered width-to-depth ratios, which further influence temperature (Spence et al. 1996). Mining efforts can also bury productive habitats near mine sites.

Mining operations can release harmful or toxic materials and their byproducts, either in association with actual mining, or in connection with machinery and materials used for mining. Mining can also introduce levels of heavy metals and arsenic that are naturally found within the streambed sediments. Tailings and discharge waters from settling ponds can result in loss of EFH and life stages of managed species. The impact degrades water quality, and levels can become high enough to prove lethal (North Pacific Fishery Management Council [Council] 1999).

Commercial operations may also involve road building (Section G.2.3), tailings disposal (Section G.4.2), and leaching of extraction chemicals, all of which may create serious impacts to EFH. Cyanide, sulfuric acid, arsenic, mercury, heavy metals, and reagents associated with such development are a threat to EFH. Improper or in-water disposal of tailings may be toxic to managed species or their prey downstream. Upland disposal of tailings in unstable or landslide prone areas can cause large quantities of toxic compounds to be released into streams or to contaminate groundwater (Council 1999). Indirectly, the sodium cyanide solution used in heap leach mining is contained in settling ponds from which groundwater and surface waters may become contaminated (Nelson et al. 1991).

Water pollution by heavy metals and acid is often associated with mineral mining operations, as ores rich in sulfides are commonly mined for gold, silver, copper, iron, zinc, and lead. When stormwater comes in contact with sulfide ores, sulfuric acid is commonly produced (West et al. 1995). Abandoned pit mines can also cause severe water pollution problems.

Recreational gold mining with such equipment as pans, motorized or nonmotorized sluice boxes, concentrators, rockerboxes, and dredges can adversely affect EFH on a local level. Commercial mining is likely to involve activities at a larger scale with much disturbance and movement of the channel involved (Oregon Water Resources Research Institute [OWRRI] 1995).

G.3.1.1.2 Recommended Conservation Measures

The following measures are adapted from recommendations in Spence et al. (1996), NMFS (2004), and Washington Department of Fish and Wildlife (WDFW) (1998). They should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. To the extent practicable, avoid mineral mining in waters, riparian areas, and floodplains containing EFH.
2. Schedule necessary in-water activities when the fewest species/least vulnerable life stages of federally managed species will be present.
3. Use an integrated environmental assessment, management, and monitoring package in accordance with state and federal law and regulations. Allow for adaptive operations to minimize adverse effects on EFH.
4. Minimize spillage of dirt, fuel, oil, toxic materials, and other contaminants into EFH. Prepare a spill prevention plan if appropriate.
5. Treat wastewater (acid neutralization, sulfide precipitation, reverse osmosis, electrochemical, or biological treatments) and recycle on site to minimize discharge to streams. Test wastewater before discharge for compliance with federal and state clean water standards.
6. Minimize opportunities for sediments to enter or affect EFH. Use methods such as contouring, mulching, and construction of settling ponds to control sediment transport. Monitor turbidity during operations, and cease operations if turbidity exceeds predetermined threshold levels. Use methods such as turbidity/sediment curtains to limit the spread of suspended sediments and minimize the area affected.
7. If possible, reclaim, rather than bury, mine waste that contains heavy metals, acid materials, or other toxic compounds if leachate can enter EFH through groundwater.
8. Restore natural contours and plant native vegetation on site after use to restore habitat function to the extent practicable. Monitor the site for an appropriate time to evaluate performance and implement corrective measures if necessary.
9. Minimize the aerial extent of ground disturbance (e.g., through phasing of operations), and stabilize disturbed lands to reduce erosion.

G.3.1.2 Sand and Gravel Mining

G.3.1.2.1 Potential Adverse Impacts

Sand and gravel mining is extensive and occurs by several methods. These include wet-pit mining (i.e., removal of material from below the water table), dry-pit mining on beaches, exposed bars, and ephemeral streambeds, and subtidal mining. Sand and gravel mining in riverine, estuarine, and coastal environments can create EFH impacts, including (1) turbidity plumes and resuspension effects, (2) removal of spawning habitat, and (3) alteration of channel morphology.

Mechanical disturbance of EFH spawning habitat by mining equipment can also lead to high mortality rates in early life stages. One result is the creation of turbidity plumes (Section G.4.1), which can move spawning habitat several kilometers downstream. Sand and gravel mining in riverine, estuarine, and coastal environments can also suspend materials at the sites (Section G.5).

Sedimentation may be a delayed effect because gravel removal typically occurs at low flow when the stream has the least capacity to transport fine sediments out of the system. Another delayed sedimentation effect results when freshets inundate extraction areas that are less stable than they were before the activity occurred. In addition, for species such as salmon, gravel operations can also interfere with migration past the site if they create physical or thermal changes, either at or downstream from the work site (OWRRI 1995).

Additionally, extraction of sand and gravel in riverine ecosystems can directly eliminate the amount of gravel available for spawning if the extraction rate exceeds the deposition rate of new gravel in the system. Gravel excavation also reduces the local supply of gravel to downstream habitats. The extent of suitable spawning habitat may be reduced where degradation reduces gravel depth or exposes bedrock (Spence et al. 1996).

Mining can also alter channel morphology by making the stream channel wider and shallower. Consequently, the suitability of stream reaches as rearing EFH may be decreased, especially during summer low-flow periods when deeper waters are important for survival. Similarly, a reduction in pool frequency may adversely affect migrating adults that require holding pools (Spence et al. 1996). Changes in the frequency and extent of bedload movement and increased erosion and turbidity can also remove spawning substrates, scour redds (resulting in a direct loss of eggs and young), or reduce their quality by deposition of increased amounts of fine sediments. Other effects that may result from sand and gravel mining include increased temperatures (from reduction in summer base flows and decreases in riparian vegetation), decreased nutrients (from loss of floodplain connection and riparian vegetation), and decreased food production (loss of invertebrates) (Spence et al. 1996).

Examples of using gravel removal to improve habitat and water quality are limited and isolated (OWRRI 1995). Deep pools created by material removal in streams appear to attract migrating adult salmon for holding. These concentrations of fish may result in high losses as a result of increased predation or recreational fishing pressure.

G.3.1.1.3 Recommended Conservation Measures

Individual gravel extraction operations should be judged in the context of their spatial, temporal, and cumulative impacts. Potential impacts to habitat should be viewed from a watershed management perspective. The following recommended conservation measures for sand and gravel mining are adapted from NMFS (2004) and OWRRI (1995). They should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. To the extent practicable, avoid sand/gravel mining in waters containing EFH. Many factors influence site selection for a gravel or sand mining site. Because of the need to incorporate technical, economic, and environmental factors, siting decisions should be considered on a case-by-case basis (U.S. Fish and Wildlife Service [USFWS] 1980).
2. Identify upland or off-channel (where the channel will not be captured) gravel extraction sites as alternatives to gravel mining in or adjacent to EFH, if possible.
3. Design, manage, and monitor sand and gravel mining operations to minimize potential direct and indirect impacts to EFH, if operations in EFH cannot be avoided. This includes, but is not limited to, migratory corridors, foraging and spawning areas, stream/river banks, intertidal areas, etc.
4. Minimize the areal extent and depth of extraction.
5. Include restoration, mitigation, and monitoring plans, as appropriate in sand/gravel extraction plans.

G.3.2 Organic and Inorganic Debris

Natural occurring flotsam, such as LWD and macrophyte wrack (i.e., kelp), plays an important role in aquatic ecosystems, including EFH. LWD and wrack promote habitat complexity and provide structure to various aquatic and shoreline habitats.

The natural deposition of LWD creates habitat complexity by altering local hydrologic conditions, nutrient availability, sediment deposition, turbidity, and other structural habitat conditions. In riverine systems, the physical structure of woody debris provides cover for managed species, creates habitats and microhabitats (e.g., pools, riffles, undercut banks, and side channels), retains gravels, and helps maintain underlying channel structure (Abbe and Montgomery 1996, Montgomery et al. 1995, Ralph et al. 1994, Spence et al. 1996). Woody debris also plays similar role in salt marsh habitats (Maser and Sedell 1994). In benthic ocean habitats, LWD enriches local nutrient availability as deep-sea wood borers convert the wood to fecal matter, providing terrestrial-based carbon to the ocean food chain (Maser and Sedell 1994). When deposited on coastal shorelines, macrophyte wrack creates microhabitats and provides a food source for aquatic and terrestrial organisms such as isopods and amphipods, which play an important role in marine food webs.

Conversely, inorganic flotsam and jetsam debris can negatively impact EFH. Inorganic marine debris is a problem along much of the coastal U.S., where it litters shorelines, fouls estuaries, entangles fish and wildlife, and creates hazards in the open ocean. Marine debris consists of a wide variety of man-made materials, including general litter, plastics, hazardous wastes, and discarded or lost fishing gear. The debris enters waterbodies indirectly through rivers and storm drains, as well as directly via ocean dumping and accidental release. Although laws and regulatory programs exist to prevent or control the problem, marine debris continues to affect aquatic resources.

G.3.2.1 Organic Debris Removal

Natural occurring flotsam, such as LWD and macrophyte wrack (i.e., kelp), is sometimes intentionally removed from streams, estuaries, and coastal shores. This debris is removed for a variety of reasons, including dam operations, aesthetic concerns, and commercial and recreational uses. However, the presence of organic debris is important for maintaining aquatic habitat structure and function. Removal can alter the ecological conditions of riverine, estuarine, and coastal ecosystems and habitats.

G.3.2.1.1 Potential Adverse Impacts

The removal of organic debris from natural systems can reduce habitat function, adversely impacting habitat quality. For example, in parts of the Pacific Northwest, reduction in LWD inputs to estuaries has reduced the number of spatially complex and diverse channel systems that provide productive salmon habitat (NRC 1996). Reductions in woody debris inputs to estuaries may also affect the ecological balance of estuarine systems by altering rates and patterns of nutrient transport, sediment deposition, and availability of in-water cover for larval and juvenile fish. In rivers and streams of the Pacific Northwest, the historic practice of removing LWD to improve navigability and facilitate log transport has altered channel morphology and reduced habitat complexity, thereby negatively affecting habitat quality for spawning and rearing salmonids (Koski 1992, Sedell and Luchessa 1982).

Beach grooming and wrack removal can substantially alter the macrofaunal community structure of exposed sand beaches (Dugan et al. 2000). It has been found that species richness, abundance, and biomass of macrofauna associated with beach wrack (e.g., sand crabs, isopods, amphipods, and polychaetes) are higher on ungroomed beaches than on those that are groomed (Dugan et al. 2000). The input and maintenance of wrack can strongly influence the structure of macrofauna communities, including the abundance of sand crabs (*Emerita analoga*) (Dugan et al. 2000), an important prey species for some managed species of fish.

G.3.2.1.2 Recommended Conservation Measures

The recommended conservation measures for organic debris include the following:

1. Leave LWD whenever possible, removing it only when it presents a threat to life or property. Otherwise, reposition, rather than remove, LWD.
2. Encourage appropriate federal, state, and local agencies to prohibit or minimize commercial removal of LWD from rivers, estuaries, and beaches.
3. Encourage appropriate federal, state, and local agencies to aid in the downstream movement of LWD around dams, culverts, and bridges wherever possible, rather than removing it from the system.
4. Educate landowners and recreationalists about the benefits of maintaining LWD.
5. Localize beach grooming practices, and minimize them whenever possible.

G.3.2.2 Inorganic Debris

G.3.2.2.1 Overview of Federal Marine Debris Regulations

Congress has passed numerous laws intended to prevent the disposal of marine debris in U.S. ocean waters. These include the Marine Protection, Research, and Sanctuaries Act, Titles I and II (also known as the Ocean Dumping Act), The Federal Water Pollution Control Act (CWA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The International Convention for the Prevention of Pollution from Ships, commonly known as MARPOL Annex V (33 CFR 151), is intended to protect the marine environment from various types of garbage by preventing ocean dumping if the ship is less than 25 nm from shore. Dumping of unground food waste and other garbage is prohibited within 12 nm from shore, and ground non-plastic or food waste may not be dumped within 3 nm of shore. The Ocean Dumping Act implements the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention) for the U.S. Section 311 of the Federal Water Pollution Control Act makes it unlawful for any person to discharge any pollutant into the waters of the U.S. except as authorized by law. CERCLA stipulates that releases of hazardous substances in reportable quantities must be reported, and the release must be removed by the responsible party. Regulations implementing these acts are intended to control marine debris from ocean sources, including galley waste and other trash from ships, recreational boaters and fishermen, and offshore oil and gas exploration and facilities.

Nationally, land-based sources of marine debris account for about 80 percent of the marine debris on beaches and in U.S. waters. Debris from these sources can originate from combined sewer overflows and storm drains, stormwater runoff, landfills, solid waste disposal, poorly maintained garbage bins, floating structures, and general littering of beaches, rivers, and open waters. Typical debris from these land-based sources includes raw or partially treated sewage, litter, hazardous materials, and discarded trash. Legislation and programs that address these land-based sources of pollution include the BEACH Act, the National Marine Debris Monitoring Program (NMDMP), the Shore Protection Act of 1989, and the CWA. The BEACH Act authorizes EPA to fund state, territorial, Tribal, and local government programs that test and monitor coastal recreational waters near public access sites for microbial contaminants and to assess and monitor floatable debris. The NMDMP is a 5-year study designed to provide statistically valid estimates of marine debris affecting the entire U.S. coastline and to determine the main sources of the debris. The Shore Protection Act contains provisions to ensure that municipal and commercial solid wastes are not deposited in coastal waters during vessel transport from source to the waste receiving station.

G.3.2.2.2 Potential Adverse Impacts

Land and ocean based marine debris is a very diverse problem, and adverse effects to EFH are likewise varied. Floating or suspended trash can directly affect fish that consume or are entangled in it. Toxic substances in plastics can kill or impair fish and invertebrates that use habitat polluted by these materials. The chemicals leach from plastics, persist in the environment, and can bioaccumulate through the food web.

Once floatable debris settles to the bottom of estuaries, coastal, and open ocean areas it may continue to cause environmental problems. Plastics and other materials with a large surface area can cover and suffocate immobile animals and plants, creating large spaces devoid of life. Currents can carry suspended debris to underwater reef habitats where the debris can become snagged, damaging these sensitive habitats. The typical floatable debris from combined sewer overflows includes street litter, sewage containing viral and bacterial pathogens, pharmaceutical by-products from human excretion, and pet wastes. It may contain condoms, tampons, and contaminated hypodermic syringes, all of which can pose physical and biological threats to EFH. Pathogens can also contaminate shellfish beds and reefs.

G.3.2.2.3 Recommended Conservation Measures

The recommended conservation measures for minimizing inorganic debris include the following:

1. Encourage proper trash disposal in coastal and ocean settings.
2. Advocate and participate in coastal cleanup activities.
3. Encourage enforcement of regulations addressing marine debris pollution and proper disposal.
4. Provide resources and technical guidance for development of studies and solutions addressing the problem of marine debris.
5. Provide resources to the public explaining the impact of marine debris and giving guidance on how to reduce or eliminate the problem.

G.3.3 Dam Operation

Dams are constructed and operated to provide sources for hydropower, water storage, and flood control. Their operation, however, can affect water quality and quantity in riverine systems.

G.3.3.1 Potential Adverse Impacts

The effects of dam construction and operation on EFH can include (1) migratory impediments, (2) water flow and current pattern shifts, (3) thermal impacts, and (4) limits on sediment and woody debris transport.

Dam construction and operation impede anadromous fish migration in streams and rivers or make fish passage impossible. Unless proper fish passage devices are in place, dams can either prevent access to productive upstream spawning habitat or can alter downstream juvenile movements. The passage of salmon through turbines, sluiceways, bypass systems, and fish ladders also affects the quality of EFH (Pacific Fishery Management Council [PFMC] 1999).

Dam operations also reduce downstream water velocities and change current patterns (PFMC 1999). These modifications can increase migration times (Raymond 1979). Water-level fluctuations, altered seasonal and daily flow regimes, reduced water velocities, and discharge volumes can affect the migratory behavior of juvenile salmonids and reduce the availability of shelter and foraging habitat (PFMC 1999).

Dams can affect the thermal regimes of streams by raising water temperatures. Changes in water temperature can affect the development and smoltification of salmonids (PFMC 1999) and adult migration (Spence et al. 1996).

Dams also limit or alter natural sediment and LWD transport processes by impeding the high flows needed to scour fine sediments and move woody debris downstream (PFMC 1999). Curtailing these resources will affect the availability of spawning gravels and change channel morphology (Spence et al. 1996).

G.3.3.2 Recommended Conservation Measures

The information in this section is adapted from PFMC 1999. The recommended conservation measures for dam operation include the following:

1. Operate facilities to create flow conditions that provide for passage, water quality, proper timing of life history stages, and properly functioning channel conditions to avoid strandings and redd dewatering.
2. Develop water and energy conservation guidelines for integration into dam operation plans and into regional and watershed-based water resource plans.
3. Provide mitigation (including monitoring and evaluation) for nonavoidable adverse effects on EFH.

G.3.4 Commercial and Domestic Water Use

Commercial and domestic water use demands to support the needs of homes, farms, and industries require a constant supply of water. Freshwater is diverted directly from lakes, streams, and rivers by means of pumping facilities, or is stored in impoundments. Because human populations are expected to continue increasing in Alaska, it is reasonable to assume that water uses, including water impoundments and diversion, will similarly increase (Gregory and Bisson 1997).

G.3.4.1 Potential Adverse Impacts

The information in this section is adapted from NMFS 1998, a, b.

The withdrawal of water can affect EFH by (1) altering natural flows and the process associated with flow rates, (2) affecting shoreline riparian habitats, (3) affecting prey bases, (4) affecting water quality, and (5) entrapping fishes. Water diversions can involve either withdrawals (reducing flow) or discharges (increasing flow). Water withdrawal will alter natural flow and stream velocity and channel depth and width. It can also change sediment and nutrient transport characteristics (Christie et al. 1993, Fajen and Layzer 1993), increase deposition of sediments, reduce depth, and accentuate diel temperature patterns (Zale et al. 1993). Loss of vegetation along streambanks and coastlines due to fluctuating water levels can decrease the availability of fish cover and reduce stability (Christie et al. 1993). Changes in the quantity and timing of stream flow alters the velocity of streams, which, in turn, affects the composition and abundance of both insect and fish populations (Spence et al. 1996). Returning irrigation water to a stream, lake, or estuary can substantially alter and degrade habitat (NRC 1989). Problems associated with return flows include increased water temperature, increased salinity, introduction of pathogens, decreased dissolved oxygen, increased toxic contaminants from pesticides and fertilizers, and increased sedimentation (Northwest Power Planning Council [NPPC] 1986). Diversions can also physically divert or entrap EFH-managed species (Section G.5.3).

G.3.4.2 Recommended Conservation Measures

The recommended conservation measures for commercial and domestic water use include the following:

1. Design projects to create flow conditions that provide for adequate passage, water quality, proper timing of life history stages, and properly functioning channels to avoid juvenile stranding and redd dewatering, as well as to maintain and restore proper channel, floodplain, riparian, and estuarine conditions.
2. Establish adequate instream flow conditions for anadromous fish.
3. Screen water diversions on fish-bearing streams, as needed.
4. Incorporate juvenile and adult fish passage facilities on all water diversion projects (e.g., fish bypass systems).
5. Where practicable, ensure that mitigation is provided for nonavoidable impacts.

G.4 ESTUARINE ACTIVITIES

G.4.1 Dredging

Dredging navigable waters creates a continuous impact primarily affecting benthic and water-column habitats in the course of constructing and operating marinas, harbors, and ports. Routine dredging (i.e., the excavation of soft-bottom substrates) is used to create deepwater navigable channels or to maintain existing channels that periodically fill with sediments. In addition, port expansion has become an almost continuous process due to economic growth, competition between ports, and significant increases in vessel size (Section G.4.3). Elimination or degradation of aquatic and upland habitats is commonplace because port expansion almost always affects open water, submerged bottoms, and, possibly, riparian zones.

G.4.1.1 Potential Adverse Impacts

The environmental effects of dredging on EFH can include (1) direct removal/burial of organisms; (2) turbidity/siltation effects, including light attenuation from turbidity; (3) contaminant release and uptake, including nutrients, metals, and organics; (4) release of oxygen consuming substances; (5) entrainment; (6) noise disturbances; and (6) alteration to hydrodynamic regimes and physical habitat.

Many EFH species forage on infaunal and bottom-dwelling organisms. Dredging may adversely affect these prey species at the site by directly removing or burying immobile invertebrates such as polychaete worms, crustacean, and other EFH prey types (Newell et al. 1998, Van der Veer et al. 1985). Similarly, the dredging activity may also force mobile animals such as fish to migrate out of the project area. Recolonization studies suggest that recovery may not be quite as straightforward. Physical factors, including particle size distribution, currents, and compaction/stabilization processes following deposition reportedly can regulate recovery after dredging events. Rates of recovery listed in the literature range from several months for estuarine muds to up to 2 to 3 years for sands and gravels. Recolonization can also take up to 1 to 3 years in areas of strong current, but up to 5 to 10 years in areas of low current. Thus, forage resources for benthic feeders may be substantially reduced.

The use of certain types of dredging equipment can result in greatly elevated levels of fine-grained mineral particles or suspended sediment concentration (SSC), usually smaller than silt, and organic particles in the water column. The associated turbidity plumes of suspended particulates may reduce light penetration and lower the rate of photosynthesis for subaquatic vegetation (Dennison 1987) and the primary productivity of an aquatic area if suspended for extended periods of times (Cloern 1987). If suspended sediments loads remain high, fish may suffer reduced feeding ability (Benfield and Minello 1996) and be prone to fish gill injury (Nightingale and Simenstad 2001a).

Sensitive habitats such as submerged aquatic vegetation beds, which provide food and shelter, may also be damaged. Eelgrass beds are critical to nearshore food web dynamics (Wyllie-Echeverria and Phillips 1994, Murphy et al. 2000). Studies have shown seagrass beds to be among the areas of highest primary productivity in the world (Herke and Rogers 1993, Hoss and Thayer 1993). This primary production, combined with other nutrients, provide high rates of secondary production in the form of fish (Herke and Rogers 1993, Good 1987, Sogard and Able 1991).

The contents of the suspended material may react with the dissolved oxygen in the water and result in short-term oxygen depletion to aquatic resources (Nightingale and Simenstad 2001a). Dredging can also disturb aquatic habitats by resuspending bottom sediments and, thereby, recirculate toxic metals (e.g., lead, zinc, mercury, cadmium, copper etc.), hydrocarbons (e.g., polyaromatics), hydrophobic organics (e.g., dioxins), pesticides, pathogens, and nutrients into the water column (EPA 2000). Toxic metals and organics, pathogens, and viruses, absorbed or adsorbed to fine-grained particulates in the material, may become biologically available to organisms either in the water column or through food chain processes.

Direct uptake of fish species by hydraulic dredging at the proposed borrow site is also an issue. Definitive information in the literature shows that elicit avoidance responses to the suction dredge entrainment occurs for both benthic and water column oriented species (Larson and Moehl 1990, McGraw and Armstrong 1990).

Dredging, as well as equipment such as pipelines used in the process (Section G.4.10), may damage or destroy spawning, nursery, and other sensitive habitats such as emergent marshes and subaquatic vegetation, including eelgrass beds and kelp beds. Dredging may also modify current patterns and water circulation of the habitat by changing the direction or velocity of water flow, water circulation, or dimensions of the waterbody traditionally used by fish for food, shelter, or reproductive purposes.

G.4.1.2 Recommended Conservation Measures

The recommended conservation measures for dredging include the following:

1. Avoid new dredging to the maximum extent practicable.
2. Where possible, minimize dredging by using natural and existing channels.
3. Site activities that would likely require dredging (such as placement of piers, docks, marinas, etc.) in deep-water areas or design such structures to alleviate the need for maintenance dredging.
4. Incorporate adequate control measures by using BMPs to minimize turbidity and dispersal of dredged material in areas where the dredging equipment would cause such effects.
5. For new dredging projects, undertake multi-season, pre-, and post-dredging biological surveys to assess the cumulative impacts to EFH and allow for implementation of adaptive management techniques.
6. Provide appropriate compensation for significant impacts (short-term, long-term, and cumulative) to benthic environments resulting from dredging.
7. Perform dredging at times when impacts to federally managed species or their prey are least likely. Avoid dredging in areas with submerged aquatic vegetation.
8. Reference all dredging latitude-longitude coordinates at the site so that information can be incorporated into a geographical information system (GIS) format. Inclusion of aerial photos may be useful to identify precise locations for long-term evaluation.
9. Test sediments for contaminants as per EPA and USACE requirements.

10. Identify excess sedimentation in the watershed that prompts excessive maintenance dredging activities, and implement appropriate management actions, if possible, to ensure that actions are taken to curtail those causes.
11. Ensure that bankward slopes of the dredged area are slanted to acceptable side slopes (e.g., 3:1) to prevent sloughing.
12. Avoid placing pipelines and accessory equipment used in conjunction with dredging operations to the maximum extent possible close to kelp beds, eelgrass beds, estuarine/salt marshes, and other high value habitat areas.

G.4.2 Material Disposal/Fill Material

The discharge of dredged materials subsequent to dredging operations or the use of fill material in aquatic habitats can result in sediments (e.g., dirt, sand, mud) covering or smothering existing submerged substrates, loss of habitat function, and adverse effects on benthic communities.

G.4.2.1 Disposal of Dredged Material

G.4.2.1.1 Potential Adverse Impacts

The disposal of dredged material can adversely affect EFH by (1) altering or destroying benthic communities, (2) altering adjacent habitats, and (3) creating turbidity plumes and introducing contaminants and/or nutrients.

Disposing dredged materials result in varying degrees of change in the physical, chemical, and biological characteristics of the substrate. Discharges may adversely affect infaunal and bottom-dwelling organisms at the site by smothering immobile organisms (e.g., prey invertebrate species) or forcing mobile animals (e.g., benthic-oriented fish species) to migrate from the area. Infaunal invertebrate plants and animals present prior to a discharge are unlikely to recolonize if the composition of the discharged material is drastically different.

Erosion, slumping, or lateral displacement of surrounding bottom of such deposits can also adversely affect substrate outside the perimeter of the disposal site by changing or destroying benthic habitat. The bulk and composition of the discharged material and the location, method, and timing of discharges may all influence the degree of impact on the substrate.

The discharge of material can result in greatly elevated levels of fine-grained mineral particles, usually smaller than silt, and organic particles in the water column (i.e., turbidity plumes). These suspended particulates may reduce light penetration and lower the rate of photosynthesis and the primary productivity of an aquatic area if suspended for long intervals. Aquatic vegetation such as eelgrass beds and kelp beds may also be affected. Managed fish species may suffer reduced feeding ability, leading to limited growth and lowered resistance to disease if high levels of suspended particulates persist. The contents of the suspended material may react with the dissolved oxygen in the water and result in oxygen depletion. Toxic metals and organics, pathogens, and viruses absorbed into or adsorbed to fine-grained particulates in the material may become biologically available to organisms either in the water column or through food chain processes.

The discharge of dredged or fill material can change the chemistry and the physical characteristics of the receiving water at the disposal site by introducing chemical constituents in suspended or dissolved form. Reduced clarity and excessive contaminants can reduce, change, or eliminate the suitability of water bodies for populations of groundfish, other fish species, and their prey. The introduction of nutrients or organic material to the water column as a result of the discharge can lead to a high BOD, which in turn can lead to reduced dissolved oxygen, thereby potentially affecting the survival of many aquatic organisms. Increases in nutrients can favor one group of organisms such as polychaetes or algae to the detriment of other types.

G.4.2.1.2 Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Study all options for disposal of dredged materials, including upland disposal sites, and select disposal sites that minimize adverse effects to EFH.
2. Where long-term maintenance dredging is anticipated, acquire and maintain disposal sites for the entire project life.
3. Encourage beneficial uses of dredged materials. Consider using dredging material for beach replenishment and construction where appropriate. When dredging material is placed in open water, consider the possibilities for enhancing marine fishery resources.
4. State and federal agencies should identify the direct and indirect impacts open-water disposal permits for dredged material may have on EFH during proposed project reviews. Determine benthic productivity by sampling prior to any discharge of fill material. Develop the sampling design with input from state and federal natural resource agencies.
5. Minimize the areal extent of any disposal site in EFH, or avoid the site entirely. Mitigate all non-avoidable adverse impacts as appropriate.

G.4.2.2 Fill Material

G.4.2.2.1 Potential Adverse Impacts

Adverse impacts to EFH from the introduction of fill material include (1) loss of habitat function and (2) changes in hydrologic patterns.

Aquatic habitats sustain remarkably high levels of productivity and support various life stages of fish species and their prey. Many times, these habitats are used for multiple purposes, including habitat necessary for spawning, breeding, feeding, or growth to maturity. The introduction of fill material eliminates those functions and permanently removes the habitat from production.

The discharge of dredged or fill material can modify current patterns and water circulation by obstructing flow, changing the direction or velocity of water flow and circulation, or otherwise changing the dimensions of a water body. As a result, adverse changes can occur in the location, structure, and dynamics of aquatic communities; shoreline and substrate erosion and deposition rates; the deposition of suspended particulates; the rate and extent of mixing of dissolved and suspended components of the water body; and water stratification (NMFS 1998, b).

G.4.2.2.2 Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH:

1. Federal, state, and local resource management and permitting agencies should address the cumulative impacts of past and current fill operations on EFH and consider them in the permitting process for individual projects.

2. Minimize the areal extent of any fill in EFH, or avoid it entirely. Mitigate all non-avoidable adverse impacts as appropriate.
3. Consider alternatives to the placement of fill into areas that support EFH. Identify and characterize EFH habitat functions/services in the project areas, so that appropriate mitigation can be determined if necessary.

G.4.3 Vessel Operations/Transportation/Navigation

The growth in Alaska coastal communities is putting demands on port districts to increase infrastructure capacity to accommodate additional vessel operations for cargo handling activities and marine transportation. Port expansion has become an almost continuous process due to economic growth, competition between ports, and significant increases in vessel size (Council 1999). In addition, increasing boat sales have put more pressure on improving and building new commercial fishing and small boat harbors.

G.4.3.1 Potential Adverse Impacts

The expansion of port facilities, vessel/ferry operations, and recreational marinas can bring additional impacts to EFH, especially by filling productive shallow water habitats. There is considerable evidence that docks and piers block sunlight penetration, alter water flow, introduce chemicals, and restrict access and navigation (Section G.4.6). The increase in hard surfaces close to the marine environment increases nonpoint surface discharges (Section G.2.2), adds debris sources, and reduces buffers between land use and the aquatic ecosystem. These include direct, indirect, and cumulative impacts on shallow subtidal, deep subtidal, eelgrass beds, mudflats, sand shoals, rock reefs, and salt marsh habitats. Such impacts would be site-specific. Some activities affecting these habitats, including new channel deepening and maintenance dredging (Section G.4.1), disposal of dredged material (Section G.4.2), reduced water quality from resuspension of contaminated sediments, ballast water discharge (Section G.4.4), and shading from overwater structures (Section G.4.6), are addressed in other sections. Additional impacts include vessel groundings, modification of water circulation (breakwaters, channels, and fill), vessel wake generation, pier lighting, anchor and prop scour, discharge of contaminants and debris, and changing natural patterns of fish movement.

Potential adverse impacts to EFH can occur during both the construction and operation phases. An increase in the number and size of vessels can generate more wave and surge effects on shorelines. These vessel-wakes, or wash events, can affect shorelines depending on the wake wave energy, the water depth, and the type of shoreline. Vessel wakes can cause a significant increase in shoreline erosion, affect wetland habitat, and increase water turbidity. Vessel prop wash can also damage aquatic vegetation and disturb sediments, which may increase turbidity and suspend contaminants (Klein 1997, Warrington 1999).

Impacts can also occur from anchor scour. Mooring buoys, when anchored in shallow nearshore waters, can drag the anchor chain across the bottom, destroying submerged vegetation and creating a circular scour hole (Walker et al. 1989, *in* Shafer 2002).

Vessel discharges, engine operations, bottom paint sloughing, boat washdowns, painting, and other vessel maintenance activities can deliver debris, nutrients, and contaminants to waterways and may degrade water quality and contaminate sediments.

Inadequate flushing of marinas also results in water quality problems (USACE 1993, Klein 1997). Poor flushing in marinas can increase temperature and raise phytoplankton populations with nocturnal dissolved oxygen level declines, resulting in organism hypoxia and pollutant inputs (Cardwell et al.

1980). An exchange of at least 30 percent of the water in the marina during a tidal change should minimize temperature increases and dissolved oxygen problems (Cardwell et al. 1980).

G.4.3.2 Recommended Conservation Measures

The recommended conservation measures for vessel operations, transportation, and navigation include the following:

1. Locate marinas in areas of low biological abundance and diversity; if possible, for example, avoid the disturbance of eelgrass or other submerged aquatic vegetation including macroalgae, mudflats, and wetlands as part of the project design. In situations where such impacts are unavoidable, consider mitigation as appropriate. Other dredging-related conservation measures are provided in Section G.4.1.
2. If practicable, excavate uplands to create marina basins rather than converting intertidal or shallow subtidal areas to deeper subtidal areas for basin creation.
3. Leave riparian buffers in place to help maintain water quality and nutrient input.
4. Should mitigation be required, include a monitoring plan to gauge the success of mitigation efforts.
5. Include low-wake vessel technology, appropriate routes, and BMPs for wave attenuation structures as part of the design and permit process. Vessels should be operated at sufficiently low speeds to reduce wake energy, and no-wake zones should be designated near sensitive habitats.
6. Incorporate BMPs to prevent or minimize contamination from ship bilge waters, antifouling paints, shipboard accidents, shipyard work, maintenance dredging and disposal, and nonpoint source contaminants from upland facilities related to vessel operations and navigation.
7. Locate mooring buoys in water deep enough to avoid grounding and to minimize the effects of prop wash. Use subsurface floats or other methods to prevent contact of the anchor line with the substrate.
8. Use catchment basins for collecting and storing surface runoff from upland repair facilities. Include parking lots and other impervious surfaces as components of the site development plan to remove contaminants prior to delivery to any receiving waters.
9. Locate facilities in areas with enough water velocity to maintain water quality levels within acceptable ranges.
10. Locate marinas where they do not interfere with drift sectors determining the structure and function of adjacent habitats.
11. To facilitate the movement of fish around breakwaters, provide a shallow shelf or "fish bench" on the outside of the breakwater.
12. Harbor facilities should be designed to include practical measures for reducing, containing, and cleaning up petroleum spills.
13. Use appropriate timing windows for construction and dredging activities to avoid potential impacts on EFH.

G.4.4 Introduction of Exotic Species

Introductions of exotic species into estuarine, riverine, and marine habitats have been well documented (Rosecchi et al. 1993, Kohler and Courtenay 1986, Spence et al. 1996) and can be intentional (e.g., for the purpose of stock or pest control) or unintentional (e.g., fouling organisms). Exotic fish, shellfish, pathogens, and plants can enter the environment from industrial shipping (e.g., as ballast), recreational boating, aquaculture (Section G.4.10), biotechnology, and aquariums. The transportation of nonindigenous organisms to new environments can have many severe impacts on habitat (Omori et al. 1994).

G.4.4.1 Potential Adverse Impacts

Long-term impacts from the introduction of nonindigenous and reared species can change the natural community structure and dynamics, lower the overall fitness and genetic diversity of natural stocks, and pass and/or introduce exotic lethal disease. Overall, exotic species introductions create five types of negative effects: (1) habitat alteration, (2) trophic alteration, (3) gene pool alteration, (4) spatial alteration, and (5) introduction of diseases. Habitat alteration includes the excessive colonization of exotic species (e.g., *Spartina* grasses), which precludes the growth of endemic organisms (e.g., eelgrass). The introduction of exotic species may alter community structure by predation on native species or by population explosions of the introduced species. For example, this has occurred in freshwater lakes on Alaska's Kenai Peninsula, where introduced northern pike have depleted local salmonid populations through rampant juvenile predation. Spatial alteration occurs when territorial introduced species compete with and displace native species. Although hybridization is rare, it may occur between native and introduced species and can result in gene pool deterioration.

Non-native plants and algae can degrade coastal and marine habitats by changing natural habitat qualities. Introduced organisms increase competition with indigenous species, or they may forage on indigenous species, which can reduce fish and shellfish populations. Long-term impacts from the introduction of nonindigenous species can change the natural community structure and dynamics, lower the overall fitness and genetic diversity of natural stocks, and pass and/or introduce exotic lethal diseases. The introduction of exotic organisms also threatens native biodiversity and could lead to changes in relative abundance of species and individuals that are of ecological and economic importance.

The introduction of bacteria, viruses, and parasites is another severe threat to EFH as it may reduce habitat quality. New pathogens or higher concentrations of disease can be spread throughout the environment, resulting in deleterious habitat conditions.

Relatively few exotic, invasive species have been documented in Alaska. It is believed that this is due to a combination of factors, including geographic isolation, harsh climate conditions and cold temperatures, fewer concentrated, highly disturbed habitat areas, and the state's stringent plant and animal transportation laws (Fay 2002).

Alaska waters are, however, vulnerable to exotic species invasion. "Potential introduction pathways include fish farms, the intentional movement of game or bait fish from one aquatic system to another, the movement of large ships and ballast water from the United States West Coast and Asia, fishing vessels docking at Alaska's busy commercial fishing ports, construction equipment, trade of live seafood, aquaculture, and contaminated sport angler gear brought to Alaska's world-renowned fishing sites" (Fay 2002).

G.4.4.2 Recommended Conservation Measures

The recommended conservation measures for preventing the introduction and spread of exotic species include the following:

1. Uphold fish and game regulations of the Alaska Board of Fisheries (AS 16.05.251) and Board of Game (AS 16.05.255), which prohibit and regulate the live capture, possession, transport, or release of native or exotic fish or their eggs.
2. Adhere to regulations and use best management practices outlined in the State of Alaska Aquatic Nuisance Species Management Plan (Fay 2002).
3. Encourage vessels to perform a ballast water exchange in marine waters (in accordance with the U.S. Coast Guard's voluntary regulations) to minimize the possibility of introducing exotic estuarine

species into similar habitats. Ballast water taken on in marine waters will contain fewer organisms, and these will be less likely to become invasive in estuarine conditions than species transported from other estuaries.
4. Discourage vessels that have not performed a ballast water exchange from discharging their ballast water into estuarine receiving waters.
5. Require vessels brought from other areas over land via trailer to clean any surfaces that may harbor non-native plant or animal species (propellers, hulls, anchors, fenders, etc.). Bilges should be emptied and cleaned thoroughly by using hot water or a mild bleach solution. These activities should be performed in an upland area to prevent introduction of non-native species during the cleaning process.
6. Treat effluent from public aquaria displays and laboratories and educational institutes using exotic species before discharge to prevent the introduction of viable animals, plants, reproductive material, pathogens, or parasites into the environment.
7. Prevent introduction of non-native plant species into aquatic and riparian ecosystems by avoiding use of non-native seed mixes or invasive, non-native landscaping materials near waterways and shorelines.
8. Encourage proper disposal of seaweeds and other plant materials used for packing purposes when shipping fish or other animals. These materials may harbor invasive species and pathogens and should be treated accordingly.

G.4.5 Pile Installation and Removal

Pilings are an integral component of many overwater and in-water structures. They provide support for the decking of piers and docks, function as fenders and dolphins to protect structures, support navigation markers, and help in the construction of breakwaters and bulkheads. Materials used in pilings include steel, concrete, wood (both treated and untreated), plastic, or a combination thereof. Piles are usually driven into the substrate by using either impact hammers or vibratory hammers. Impact hammers consist of a heavy weight that is repeatedly dropped onto the top of the pile, driving it into the substrate. Vibratory hammers use a combination of a stationary, heavy weight and vibration, in the plane perpendicular to the long axis of the pile, to force the pile into the substrate. The type of hammer used depends on a variety of factors, including pile material and substrate type. Impact hammers can be used to drive all types of piles, while vibratory hammers are generally most efficient at driving piles with a cutting edge (e.g., hollow steel pipe) and are less efficient at driving displacement piles (those without a cutting edge that must displace the substrate). Displacement piles include solid concrete, wood, and closed-end steel pipe. While impact hammers are able to drive piles into most substrates (including hardpan, glacial till, etc.), vibratory hammers are limited to softer, unconsolidated substrates (e.g., sand, mud, and gravel). Because vibratory hammers do not use force to drive the piles, the bearing capacity is not known, and the piles must often be proofed with an impact hammer. This involves striking the pile a number of times with the impact hammer to ensure that it meets the designed bearing capacity. Under certain circumstances, piles may be driven using a combination of vibratory and impact hammers. The vibratory hammer makes positioning and plumbing of the pile easier; therefore, it is often used to drive the pile through the soft, overlying material. Once the pile stops penetrating the sediment, the impact hammer is used to finish driving the pile to final depth. An additional advantage of this method is that the vibratory hammer can be used to extract and reposition the pile, while the impact hammer cannot.

Overwater structures usually must meet seismic stability criteria, requiring that the supporting piles are attached to, or driven into, the underlying hard material. This requirement often means that at least some impact driving is necessary. Piles that do not have to be seismically stable, including temporary piles, fender piles, and some dolphin piles, may be driven with a vibratory hammer, providing the type of pile and sediments are appropriate.

Piles can be removed using a variety of methods, including vibratory hammer, direct pull, clam shell grab, or cutting/breaking the pile below the mudline. Vibratory hammers can be used to remove all types of pile, including wood, concrete, and steel. Old brittle piles may, however, break under the vibrations; this may necessitate using another method. The direct pull method involves placing a choker around the pile and pulling upward with a crane or other equipment. Broken stubs in soft substrates can be removed with a clam shell and crane, although suitable conditions rarely exist in Alaska. In this method, the clam shell grips the pile near the mudline and pulls it out. More commonly, piles may be cut or broken below the mudline, leaving the buried section in place.

G.4.5.1 Pile Driving

G.4.5.1.1 Potential Adverse Impacts

Pile driving can generate intense underwater sound pressure waves that may adversely affect EFH. These pressure waves have been shown to injure and kill fish (CalTrans 2001, Longmuir and Lively 2001, Stotz and Colby 2001, Stadler, pers. obs. 2002). Injuries associated directly with pile driving are poorly studied, but include rupture of the swimbladder and internal hemorrhaging (CalTrans 2001; Abbott and Bing-Sawyer 2002; Stadler, pers. obs. 2002). Sound pressure levels (SPLs) 100 decibels (dB) above the threshold for hearing are thought to be sufficient to damage the auditory system in many fishes (Hastings 2002).

The type and intensity of the sounds produced during pile driving depend on a variety of factors, including, but not limited to, the type and size of the pile, the firmness of the substrate into which the pile is being driven, the depth of water, and the type and size of the pile-driving hammer. SPLs are positively correlated with the size of the pile, as more energy is required to drive larger piles. Wood and concrete piles appear to produce lower sound pressures than hollow-steel piles of a similar size, although it is unclear if the sounds produced by wood or concrete piles are harmful to fishes. Hollow-steel piles as small as 14 inches (35.5 centimeters) in diameter have been shown to produce SPLs that can injure fish (Reyff 2003). Firmer substrates require more energy to drive piles and produce more intense sound pressures. Sound attenuates more rapidly with distance from the source in shallow water than it does in deep water (Rogers and Cox 1988).

Driving large hollow-steel piles with impact hammers produces intense, sharp spikes of sound that can easily reach levels injurious to fish. Vibratory hammers, on the other hand, produce sounds of lower intensity, with a rapid repetition rate. A key difference between the sounds produced by impact hammers and those produced by vibratory hammers is the responses they evoke in fish. When exposed to sounds that are similar to those of a vibratory hammer, fish consistently displayed an avoidance response (Enger et al. 1993, Dolat 1997, Knudsen et al. 1997, Sand et al. 2000), and they did not habituate to the sound, even after repeated exposure (Dolat 1997, Knudsen et al. 1997). Fishes may respond to the first few strikes of an impact hammer with a startle response. After these initial strikes, the startle response wanes, and the fishes may remain within the field of a potentially harmful sound (Dolat 1997, NMFS 2001). The differential responses to these sounds are due to the differences in the duration and frequency of the sounds. When compared to impact hammers, the sounds produced by vibratory hammers are of longer duration (minutes versus milliseconds) and have more energy in the lower frequencies (15 to 26 hertz [hz] versus 100 to 800 hz) (Würsig, et al. 2000, Carlson et al. 2001). Studies have shown that fish respond to particle acceleration of 0.01 meter per second squared (m/s^2) at infrasound frequencies, that the response to infrasound is limited to the nearfield (less than 1 wavelength), and that the fish must be exposed to the sound for several seconds (Enger et al. 1993, Knudsen et al. 1994, Sand et al. 2000). Impact hammers, however, produce such short spikes of sound with little energy in the infrasound range, that fish fail to respond to the particle motion (Carlson et al. 2001). Thus, impact hammers may be more harmful than vibratory hammers because they produce more intense pressure waves and because the sounds produced do not elicit an avoidance response in fishes, which exposes them to those harmful pressures for longer periods.

The degree to which an individual fish exposed to sound will be affected depends on a number of variables, including (1) species of fish, (2) fish size, (3) presence of a swimbladder, (4) physical condition of the fish, (5) peak sound pressure and frequency, (6) shape of the sound wave (rise time), (7) depth of the water around the pile, (8) depth of the fish in the water column, (9) amount of air in the water, (10) size and number of waves on the water surface, (11) bottom substrate composition and texture, (12) effectiveness of bubble curtain sound/pressure attenuation technology, (13) tidal currents, and (14) presence of predators.

Depending on these factors, effects on fish can range from changes in behavior to immediate mortality. There are little data on the SPL required to injure fish. Short-term exposure to peak SPLs above 190 dB (re:1 μPa) is thought to impose physical harm on fish (Hastings 2002). However, 155 dB (re:1 μPa) may be sufficient to stun small fish temporarily (personal communication, J. Miner, Gunderboom, Inc., Anchorage, Alaska, 2002). Stunned fish, while perhaps not physically injured, are more susceptible to predation. Small fish are more prone to injury by intense sound than are larger fish of the same species (Yelverton et al. 1975). For example, a number of surfperches (*Cymatogaster aggregata* and *Embiotoca lateralis*) were killed during impact pile driving (Stadler, pers. obs. 2002). Most of the dead fish were the smaller *C. aggregata* and similar sized specimens of *E. lateralis*, even though many larger *E. lateralis* were in the same area. Dissections revealed that the swimbladder of the smallest fish (80 millimeter [mm] forklength [FL]) was completely destroyed, while that of the largest individual (170 mm FL) was nearly intact, indicating a size-dependent effect. The SPLs that killed these fish are unknown. Of the reported fish kills associated with pile driving, all have occurred during use of an impact hammer on hollow-steel piles (Longmuir and Lively 2001, NMFS 2001, Stotz and Colby 2001, NMFS 2003).

Systems successfully designed to reduce the adverse effects of underwater SPLs on fish have included the use of air bubbles. Both confined (i.e., metal or fabric sleeve) and unconfined air bubble systems have been shown to attenuate underwater sound pressures up to 28 dB (Würsig et al. 2000, Longmuir and Lively 2001, Christopherson and Wilson 2002, Reyff and Donovan 2003). When using an unconfined air bubble system in areas of strong currents, it is critical that the pile be fully contained within the bubble curtain. To accomplish this when designing the system, adequate air flow and ring spacing, both vertically and in terms of distance from the pile, are factors that should be considered.

G.4.5.1.2 Recommended Conservation Measures

The recommended conservation measures for pile driving include the following:

1. Install hollow-steel piles with an impact hammer at a time of year when larval and juvenile stages of fish species with designated EFH are not present. If the first measure is not possible, then the following measures regarding pile driving should be incorporated when practicable to minimize adverse effects:
2. Drive piles during low tide when they are located in intertidal and shallow subtidal areas.
3. Use a vibratory hammer when driving hollow-steel piles. When impact hammers are required due to seismic stability or substrate type, drive the pile as deep as possible with a vibratory hammer before using the impact hammer.
4. Implement measures to attenuate the sound should SPLs exceed the 180 dB (re:1 μPa) threshold. If sound pressure levels are anticipated to exceed acceptable limits, implement appropriate mitigation measures when practicable. Methods to reduce the sound pressure levels include, but are not limited to, the following:
    a) Surround the pile with an air bubble curtain system or air-filled coffer dam.

   b) Because the sound produced has a direct relationship to the force used to drive the pile, use a smaller hammer to reduce the sound pressures.
   c) Use a hydraulic hammer if impact driving cannot be avoided. The force of the hammer blow can be controlled with hydraulic hammers; reducing the impact force will reduce the intensity of the resulting sound.
5. Drive piles when the current is reduced (i.e., centered around slack current) in areas of strong current to minimize the number of fish exposed to adverse levels of underwater sound.

G.4.5.2 Pile Removal

G.4.5.2.1 Potential Adverse Impacts

The primary adverse effect of removing piles is the suspension of sediments, which may result in harmful levels of turbidity and release of contaminants contained in those sediments (Section G.4.1). Vibratory pile removal tends to cause the sediments to slough off at the mudline, resulting in relatively low levels of suspended sediments and contaminants. Vibratory removal of piles is gaining popularity because it can be used on all types of piles, providing that they are structurally sound. Breaking or cutting the pile below the mudline may suspend only small amounts of sediment, providing that the stub is left in place, and little digging is required to access the pile. Direct pull or use of a clamshell to remove broken piles may, however, suspend large amounts of sediment and contaminants. When the piling is pulled from the substrate using these two methods, sediments clinging to the piling will slough off as it is raised through the water column, producing a potentially harmful plume of turbidity and/or contaminants. The use of a clamshell may suspend additional sediment if it penetrates the substrate while grabbing the piling.

While there is a potential to adversely affect EFH during the removal of piles, many of the piles removed are old creosote-treated timber piles. In some cases, the long-term benefits to EFH obtained by removing a chronic source of contamination may outweigh the temporary adverse effects of turbidity.

G.4.5.2.2 Recommended Conservation Measures

The recommended conservation measures for pile removal include the following:

1. Remove piles completely rather than cutting or breaking them off, if they are structurally sound.
2. Minimize the suspension of sediments and disturbance of the substrate when removing piles. Measures to help accomplish this include, but are not limited to, the following:
   a) When practicable, remove piles with a vibratory hammer, rather than using the direct pull or clamshell method.
   b) Remove the pile slowly to allow sediment to slough off at, or near, the mudline.
   c) The operator should first hit or vibrate the pile to break the bond between the sediment and the pile to minimize the potential for the pile to break, as well as to reduce the amount of sediment sloughing off the pile during removal.
   d) Encircle the pile, or piles, with a silt curtain that extends from the surface of the water to the substrate.
3. Complete each pass of the clamshell to minimize suspension of sediment if pile stubs are removed with a clamshell.
4. Place piles on a barge equipped with a basin to contain all attached sediment and runoff water after removal. Creosote-treated timber piles should be disposed of properly to prevent reuse in the marine environment, and all debris, including attached contaminated sediments, should be disposed of in an approved upland facility.
5. Using a pile driver, drive broken/cut stubs far enough below the mudline to prevent release of contaminants into the water column as an alternative to their removal.

G.4.6 Overwater Structures

Overwater structures include commercial and residential piers and docks, floating breakwaters, barges, rafts, booms, and mooring buoys. These structures typically are located in intertidal areas out to about 49 feet (15 meters) below the area exposed by the mean lower low tide (i.e., the shallow subtidal zone). Light, wave energy, substrate type, depth, and water quality are the primary factors controlling the plant and animal assemblages found at a particular site. Overwater structures and associated activities can alter these factors and interfere with key ecological functions such as spawning, rearing, and refugia. Site-specific factors (e.g., water clarity, current, depth, etc.) and the type and use of a given overwater structure determine the occurrence and magnitude of these impacts.

G.4.6.1 Potential Adverse Impacts

Overwater structures and associated developments may adversely affect EFH in a variety of ways, primarily by changes in ambient light conditions, alteration of the wave and current energy regime, and activities associated with the use and operation of the facilities (Nightingale and Simenstad 2001b).

Overwater structures can create shade, which reduces the light levels below the structure. The size, shape, and intensity of the shadow cast by a particular structure depends upon its height, width, construction materials, and orientation. High and narrow piers and docks produce narrower, more diffuse shadows than do low and wide structures. Increasing the numbers of pilings used to support a given pier enhances the shade pilings cast on the under-pier environment. In addition, less light is reflected underneath structures built with light-absorbing materials (e.g., wood) than under structures built with light-reflecting materials (e.g., concrete or steel). Structures that are oriented north-south produce a shadow that moves across the bottom throughout the day, resulting in a smaller area of permanent shade than those that are oriented east-west.

The shadow cast by an overwater structure affects both the plant and animal communities below the structure. Distributions of plants, invertebrates, and fishes appear severely limited in under-dock environments when compared to adjacent, unshaded, vegetated habitats. Light is the most important factor affecting aquatic plants. Under-pier light levels can fall below threshold amounts for the photosynthesis of diatoms, benthic algae, eelgrass, and associated epiphytes and other autotrophs. These photosynthesizers are an essential part of nearshore habitat and the estuarine and nearshore foodwebs that support many species of marine and estuarine fishes. Eelgrass and other macrophytes can be reduced or eliminated, even through partial shading of the substrate, and have little chance to recover.

Fishes rely on visual cues for spatial orientation, prey capture, schooling, predator avoidance, and migration. The reduced-light conditions found under an overwater structure may limit the ability of fishes, especially juveniles and larvae, to perform these essential activities. Shading from overwater structures may also reduce prey organism abundance and the complexity of the habitat by reducing aquatic vegetation and phytoplankton abundance (Kahler et al. 2000, Haas et al. 2002). Glasby (1999) found that epibiotic assemblages on pier pilings at marinas subject to shading were markedly different than in surrounding areas. Other studies have shown shaded epibenthos to be reduced relative to that in open areas. These factors are thought to be responsible for the observed reductions in juvenile fish populations found under piers and the reduced growth and survival of fishes held in cages under piers, when compared to open habitats (Able et al. 1998, Duffy-Anderson and Able 1999).

The shadow cast by an overwater structure may increase predation on managed species of fish by creating a light/dark interface that allows ambush predators to remain in a darkened area (barely visible to prey) and watch for prey to swim by against a bright background (high visibility) (Helfman 1981). Prey species moving around the structure are unable to see predators in the dark area under the structure and are more susceptible to predation. Furthermore, the reduced vegetation (i.e., eelgrass) densities associated with overwater structures decrease the available refugia from predators.

Wave energy and water transport alterations from overwater structures can impact the nearshore detrital foodweb by altering the size, distribution, and abundance of substrate and detrital materials. Disruption of longshore transport can alter substrate composition and present potential barriers to the natural processes that build spits and beaches and provide substrates required for plant propagation, fish and shellfish settlement and rearing, and forage fish spawning.

Pilings can alter adjacent substrates with increased shell deposition from piling communities and changes to substrate bathymetry (Section G.4.5). Changes in substrate type can alter the nature of the flora and fauna native to a given site. In the case of pilings, native dominant communities typically associated with sand, gravel, mud, and eelgrass substrates are replaced by communities associated with shell hash substrates.

Treated wood used for pilings and docks releases contaminants into saltwater environs. PAHs are commonly released from creosote-treated wood. PAHs can cause a variety of deleterious effects (cancer, reproductive anomalies, immune dysfunction, and growth and development impairment) to exposed fish (Johnson et al. 1999, Johnson 2000, Stehr et al. 2000). Wood also is commonly treated with other chemicals such as ammoniacal copper zinc arsenate (ACZA) and chromated copper arsenate (CCA) (Poston 2001). These preservatives are known to leach into marine waters for a relatively short time after installation, but the rate of leaching varies considerably, depending on many factors. Concrete and steel, on the other hand, are relatively inert and do not leach contaminants into the water.

Construction and maintenance of overwater structures often involve driving pilings (Section G.4.5) and dredging navigation channels (Section G.4.1). Both activities may also adversely affect EFH.

While the effect of some individual overwater structures on EFH may be minimal, the overall impact may be substantial when considered cumulatively. The additive effects of these structures increase the overall magnitude of impact and reduce the ability of EFH to support native plant and animal communities.

G.4.6.2 Recommended Conservation Measures

The recommended conservation measures for overwater structures include the following:

1. Use upland boat storage whenever possible to minimize need for overwater structures.
2. Locate overwater structures in deep enough waters to avoid intertidal and shade impacts, minimize or preclude dredging, minimize groundings, and avoid displacement of submerged aquatic vegetation, as determined by a preconstruction survey.
3. Design piers, docks, and floats to be multiuse facilities to reduce the overall number of such structures and to limit impacted nearshore habitat.
4. Incorporate measures that increase the ambient light transmission under piers and docks. These measures include, but are not limited to, the following:
   a) Maximize the height of the structure, and minimize the width of the structure to decrease the shade footprint and using grated decking material.
   b) Use reflective materials (e.g., concrete or steel instead of materials that absorb light such as wood) on the underside of the dock to reflect ambient light.
   c) Use the fewest number of pilings necessary to support the structures to allow light into under-pier areas and minimize impacts to the substrate.
   d) Align piers, docks, and floats in a north-south orientation to allow the arc of the sun to cross perpendicular to the structure and to reduce the duration of light limitation.

5. Use floating rather than fixed breakwaters whenever possible, and remove them during periods of low dock use. Encourage seasonal use of docks and off-season haul-out.
6. Locate floats in deep water to avoid light limitation and grounding impacts to the intertidal or shallow subtidal zone.
7. Maintain at least 1 foot (0.30 meter) of water between the substrate and the bottom of the float at extreme low tide.
8. Conduct in-water work when managed species and prey species are least likely to be impacted.
9. To the extent practicable, avoid the use of treated wood timbers or pilings. If practicable, use alternative materials such as untreated wood, concrete, or steel.
10. Mitigate for unavoidable impacts to benthic habitats. Mitigation should be adequate, monitored, and adaptively managed.

G.4.7 Flood Control/Shoreline Protection

Protecting riverine and estuarine communities from flooding events can result in varying degrees of change in the physical, chemical, and biological characteristics of existing shoreline and riparian habitat. The use of dikes and berms can also have long-term adverse effects on tidal marsh and estuarine habitats. Tidal marshes are highly variable, but typically have freshwater vegetation at the landward side, saltwater vegetation at the seaward side, and gradients of species inbetween that are in equilibrium with the prevailing climatic, hydrographic, geological, and biological features of the coast. These systems normally drain through highly dendritic tidal creeks that empty into the bay or estuary. Freshwater entering along the upper edges of the marsh drains across the surface and enters the tidal creeks. Structures placed for coastal shoreline protection include, but are not limited to, concrete or wood seawalls, rip-rap revetments (sloping piles of rock placed against the toe of the dune or bluff in danger of erosion from wave action), dynamic cobble revetments (natural cobble placed on an eroding beach to dissipate wave energy and prevent sand loss), vegetative plantings, and sandbags.

G.4.7.1 Potential Adverse Impacts

Dikes, levees, ditches, or other water controls at the upper end of a tidal marsh can cut off all tributaries feeding the marsh, preventing freshwater flushing and annual flushing, annual renewal of sediments and nutrients, and the formation of new marshes. Water controls within the marsh proper intercept and carry away freshwater drainage, block freshwater from flowing across seaward portions of the marsh, increase the speed of runoff of freshwater to the bay or estuary, lower the water table, permit saltwater intrusion into the marsh proper, and create migration barriers for aquatic species. In deeper channels where reducing conditions prevail, large quantities of hydrogen sulfide are produced. These quantities are toxic to marsh grasses and other aquatic life. Acid conditions of these channels can also result in release of heavy metals from the sediments.

Long-term effects on the tidal marsh include land subsidence (sometimes even submergence), soil compaction, conversion to terrestrial vegetation, greatly reduced invertebrate populations, and general loss of productive wetland characteristics. Loss of these low-salinity environments reduces estuarine fertility, restricts suitable habitat for aquatic species, and creates abnormally high salinity during drought years. Low-salinity environments form a barrier that prevents the entrance of many marine species, including competitors, predators, parasites, and pathogens.

Armoring of shorelines to prevent erosion and to maintain or create shoreline real estate simplifies habitats, reduces the amount of intertidal habitat, and affects nearshore processes and the ecology of numerous species (Williams and Thom 2001). Hydraulic effects on the shoreline include increased energy seaward of the armoring, reflected wave energy, dry beach narrowing, substrate coarsening, beach steepening, changes in sediment storage capacity, loss of organic debris, and downdrift sediment starvation (Williams and Thom 2001). Installation of breakwaters and jetties can result in community changes from burial or removal of resident biota, changes in cover and preferred prey species, and predator attraction (Williams and Thom 2001). As with armoring, breakwaters and jetties modify hydrology and nearshore sediment transport, as well as movement of larval forms of many species (Williams and Thom 2001).

G.4.7.2 Recommended Conservation Measures

The recommended conservation measures for flood control and shoreline protection include the following:

1. Minimize the loss of riparian habitats as much as possible.
2. Do not undertake diking and draining of tidal marshlands and estuaries.
3. Wherever possible, use soft approaches (such as beach nourishment, vegetative plantings, and placement of LWD) to shoreline modifications.
4. Include efforts to preserve and enhance EFH by providing new gravel for spawning areas, removing barriers to natural fish passage, and using weirs, grade control structures, and low-flow channels to provide the proper depth and velocity for fish.
5. Construct a low-flow channel to facilitate fish passage and help maintain water temperature in reaches where water velocities require armoring of the riverbed.
6. Offset unavoidable impacts to in-stream fish habitat by providing rootwads, deflector logs, boulders, and rock weirs and by planting shaded riverine aquatic cover vegetation.
7. Use an adaptive management plan with ecological indicators to oversee monitoring and to ensure that mitigation objectives are met. Take corrective action as needed.

G.4.8 Log Transfer Facilities/In-water Log Storage

Rivers, estuaries, and bays were historically the primary ways to transport and store logs in the Pacific Northwest. Log storage within the bays and estuaries remains an issue in several Pacific Northwest bays. Using estuaries and bays and nearby uplands for storage of logs is common in Alaska, with most LTFs found in Southeast Alaska and a few located in Prince William Sound.

G.4.8.1 Potential Adverse Impacts

Log handling and storage in the estuary and intertidal zones of rivers can result in modification of benthic habitat and water quality degradation within the area of bark deposition (Levings and Northcote 2004). An LTF is a facility that is wholly or partly constructed in waters of the U.S. and that is used to transfer commercially harvested logs to or from a vessel or log raft, including the formation of a log raft (EPA 2000). LTFs may include a crane, A-frame structure, conveyor, or a slide or ramp to move logs into the water. Logs can also be placed in the water at the site by helicopters and barges. The physical adverse impacts from these structures are similar in many ways to those of floating docks and other over-water structures (Section G.4.6).

EFH may also be physically impacted by activities associated with LTFs. Bark and wood debris may accumulate as a result of the abrasion of log surfaces from transfer equipment and impact EFH. After the logs have entered the water, they usually are bundled into rafts and hooked to a tug for shipment. In the process, bark and other wood debris can pile up on the ocean floor. The piles can smother clams, mussels, some seaweed, kelp, and grasses, with the bark sometimes remaining for decades. Accumulation of bark debris in shallow and deep-water environments has resulted in locally decreased epifaunal macrobenthos richness and abundance (Kirkpatrick et al. 1998, Jackson 1986).

Log storage may also result in a release of soluble organic compounds within the bark pile. Log bark may affect groundfish habitat by significantly increasing oxygen demand within the area of accumulation (Pacific Northwest Pollution Control Council [PNPCC] 1971). High oxygen demand can lead to an anaerobic zone within the bark pile where toxic sulfide compounds are generated, particularly in brackish and marine waters. Reduced oxygen levels, anaerobic conditions, and the presence of toxic sulfide compounds can result in reduced localized habitat value for groundfish species and their forage base. In addition, soils at onshore facilities where logs are decked can become contaminated with gasoline, diesel fuel, solvents, etc., from trucks and heavy equipment. These contaminants could leach into nearshore EFH.

The physical, chemical, and biological impacts of LTF operations can be substantially reduced by adherence to appropriate siting and operational constraints. In 1985, the Alaska Timber Task Force (ATTF) developed guidelines to "delineate the physical requirements necessary to construct a log transfer and associated facilities, and in context with requirements of applicable law and regulations, methods to avoid or control potential impacts from these facilities on water quality, aquatic and other resources." Since 1985, the ATTF guidelines have been applied to new LTFs through the requirements of NPDES permits and other state and federal programs (EPA 1996). Adherence to the ATTF operational and siting guidelines and BMPs in the National Pollution Discharge Elimination System (NPDES) General Permit will reduce (1) the amount of bark and wood debris that enters the marine and coastal environment, (2) the potential for displacement or harm to aquatic species, and (3) the accumulation of bark and wood debris on the ocean floor. The following conservation measures reflect those guidelines.

G.4.8.2 Recommended Conservation Measures

The recommended conservation measures for log transfer facilities and in-water log storage include the following:

1. Restrict or eliminate storage and handling of logs from waters where state and federal water quality standards cannot be met at all times outside of the authorized zone of deposition.
2. Minimize potential impacts of log storage by employing effective bark and wood debris control, collection, and disposal methods at log dumps, raft building areas, and mill-side handling zones; avoiding free-fall dumping of logs; using easy let-down devices for placing logs in the water; and bundling logs before water storage (bundles should not be broken except on land and at millside).
3. Do not store logs in the water if they will ground at any time or shade sensitive aquatic vegetation such as eelgrass.
4. Avoid siting log-storage areas and LTFs in sensitive habitat and areas important for specified species, as required by the ATTF guidelines.
5. Site log storage areas and LTFs in areas with good currents and tidal exchanges.
6. Use land-based storage sites where possible, with the goal of eliminating in-water storage of logs.
7. Also see the following link for LTF guidelines: http://www.fs.fed.us/r10/TLMP/F_PLAN/APPEND_G.PDF.

G.4.9 Utility Line/Cables/Pipeline Installation

With the continued development of coastal regions comes greater demand for the installation of cables, utility lines for power and other services, and pipelines for water, sewage, etc. The installation of pipelines, utility lines, and cables can have direct and indirect impacts on the offshore, nearshore, estuarine, wetland, beach, and rocky shore coastal zone habitats. Many of the primary and direct impacts occur during the construction phase of installation, such as ground disturbance in the clearing of the right-of-way, access roads, and equipment staging areas. Indirect impacts can include increased turbidity, saltwater intrusion, accelerated erosion, and introduction of urban and industrial pollutants.

G.4.9.1 Potential Adverse Impacts

Adverse effects on EFH from the installation of pipelines, utility lines, and cables can occur through (1) destruction of organisms and habitat, (2) turbidity impacts, (3) resuspension of contaminants, and (4) changes in hydrology.

Destruction of organisms and habitats can occur in pipeline or cable right of way. This destruction can lead to long-term or permanent damage depending on the degree and type of habitat disturbance and the mitigation measures employed. Shallow-water environments, rocky reefs, nearshore and offshore rises, salt and freshwater marshes (wetlands), and estuaries are more likely to be adversely impacted than open-water habitats. This is due to their higher sustained biomass and lower water volumes, which decrease their ability to dilute and disperse suspended sediments (Gowen 1978).

Because vegetated coastal wetlands provide forage for and protection of commercially important invertebrates and fish, marsh degradation due to plant mortality, soil erosion, or submergence will eventually decrease productivity. Vegetation loss and reduced soil elevation within pipeline construction corridors should be expected with the continued use of current double-ditching techniques (Polasek 1997).

Increased water turbidity from higher than normal sediment loading can result in decreased primary production. Depending on the time of year of the construction, adverse impacts can occur, such as during highly productive spring phytoplankton blooms or times when organisms are already under stressed conditions. Changes in turbidity can temporarily alter phytoplankton communities. Depending upon the severity of the turbidity, these changes in water clarity can affect the EFH habitat functions of species higher in the food chain.

Another impact is resuspension of contaminants such as heavy metals and pesticides from the sediment, which can have lethal effects (Gowen 1978). Spills of petroleum products, solvents, and other construction-related material can also adversely affect habitat.

Pipeline canals have the potential to change the hydrology of coastal areas by (1) facilitating rapid drainage of interior marshes during low tides or low precipitation, (2) reducing or interrupting freshwater inflow and associated littoral sediments, and (3) allowing saltwater to move farther inland during periods of high tides (Chabreck 1972). Saltwater intrusion into freshwater marshes often causes loss of salt-intolerant emergent and submerged aquatic plants (Chabreck 1972, Pezeshki 1987), erosion, and net loss of soil organic matter (Craig et al. 1979).

G.4.9.2 Recommended Conservation Measures

The recommended conservation measures for utility line, cables, and pipeline installation include the following:

1. Align crossings along the least environmentally damaging route. Avoid sensitive habitats such as hard-bottom (e.g., rocky reefs), cold-water corals, submerged aquatic vegetation, oyster reefs, emergent marsh, and mud flats. If impacts remain after all appropriate and practicable avoidance and minimization has been achieved, consider compensatory mitigation.
2. Use horizontal directional drilling where cables or pipelines would cross anadromous fish streams, salt marsh, vegetated inter-tidal zones, or steep erodible bluff areas adjacent to the inter-tidal zone to avoid surface disturbances.
3. Avoid construction of permanent access channels since they disrupt natural drainage patterns and destroy wetlands through excavation, filling, and bank erosion.

4. Store and contain excavated material on uplands. If storage in wetlands or waters cannot be avoided, use alternate stockpiles to allow continuation of sheet flow. Store stockpiled materials on construction cloth rather than bare marsh surfaces, sea grasses, or reefs.
5. Backfill excavated wetlands with either the same or comparable material capable of supporting similar wetland vegetation. Restore original marsh elevations. Stockpile topsoil and organic surface material such as root mats separately, and return it to the surface of the restored site. Use adequate material so that the proper preproject elevation is attained following settling and compaction of the material. If excavated materials are insufficient to accomplish this, use similar particle-size material to restore the trench to the required elevation. After backfilling, implement erosion protection measures where needed.
6. Use existing rights-of-way whenever possible to lessen overall encroachment and disturbance of wetlands.
7. Bury pipelines and submerged cables where possible. Unburied pipelines, or pipelines buried in areas where scouring or wave activity eventually exposes them, run a much greater risk of damage leading to leaks or spills.
8. Remove inactive pipelines and submerged cables unless they are located in sensitive areas (e.g., marsh, reefs, sea grass, etc.) or in areas that present no safety hazard. If allowed to remain in place, ensure that pipelines are properly pigged, purged, filled with seawater, and capped before abandonment in place.
9. Use silt curtains or other type barriers to reduce turbidity and sedimentation near the project site.
10. Limit access for equipment to the immediate project area. Tracked vehicles are preferred over wheeled vehicles. Consider using mats and boards to avoid sensitive areas. Caution equipment operators to avoid sensitive areas. Clearly mark sensitive areas to ensure that equipment operators do not traverse them.
11. Limit construction equipment to the minimum size necessary to complete the work. Use shallow-draft equipment to minimize effects and to eliminate the necessity for temporary access channels. Minimize the size of the pipeline trench proper. Use the push-ditch method, in which the trench is immediately backfilled. This reduces the impact duration, and it should, therefore, be used when possible.
12. Conduct construction during the time of year when it will have the least impact on sensitive habitats and species.
13. Suspend transmission lines beneath existing bridges or conduct directional boring under streams to reduce the environmental impact. If transmission lines span streams, site towers at least 200 feet from streams.

G.4.9.3 Activities on the Continental Shelf

14. Shunt drill cuttings through a conduit and either discharge the cuttings near the sea floor, or transport them ashore.
15. To the extent practicable, locate drilling and production structures, including pipelines, at least 1 mile (1.6 kilometers) from the base of a hard-bottom habitat.
16. To avoid and minimize adverse impacts to managed species, implement the following to the extent practicable:
    a) Bury pipelines at least 3 feet (0.9 meter) beneath the sea floor, whenever possible. Particular considerations (i.e., currents, ice scour) may require deeper burial or weighting to maintain adequate cover. Buried pipeline and cables should be examined periodically for maintenance of adequate earthen cover.
    b) Where burial is not possible, such as in hard-bottomed areas, attach pipelines and cables to substrate to minimize conflicts with fishing gear. Wherever possible, mark the route by using lighted buoys and/or lighted ranges on platforms to reduce the risk of damage to fishing gear and the pipelines.

c) Locate alignments along routes that will minimize damage to marine and estuarine habitat. Avoid laying cable over high-relief bottom habitat and across live bottom habitats such as coral and sponge. If coral or sponge habitats are encountered, NMFS is interested in position and description information.
d) Where user conflicts are likely, consult and coordinate with fishing stakeholder groups during the route-planning process to minimize conflict.

G.4.10 Commercial Utilization of Habitat

Productive embayments are often used for commercial culturing and harvesting operations. These locations provide protected waters which serve as sites for oyster and mussel culturing. These operations may occur in areas of productive eelgrass beds. In 1988, Alaska passed the Alaska Aquatic Farming Act which is designed to encourage establishment and growth of an aquatic farming industry in the state. The Act establishes four criteria for issuance of an aquatic farm permit, including the requirement that the farm may not significantly affect fisheries, wildlife, or other habitats in an adverse manner. Aquatic farm permits are issued by the Alaska Department of Natural Resources.

G.4.10.1 Potential Adverse Impacts

Adverse impacts to EFH by operations that directly or indirectly use habitat include (1) discharge of organic waste, (2) shading and direct impacts to the seafloor, (3) risk of introducing undesirable species, and (4) impacts on estuarine food webs.

Intensive shellfish mariculture can result in the buildup of organic solid waste in the vicinity of the farm in higher concentrations than would occur naturally. The buildup of organic materials on the sea floor can impact the composition and diversity of the bottom-dwelling community (e.g., prey organisms for fish). Growth of submerged aquatic vegetation, which can provide shelter and nursery habitat for a number of fish species and their prey, can be inhibited by shading effects or, in extreme cases, can be smothered by organic debris. Disruption of eelgrass habitat by management activities (e.g., dumping of shell with spawn on eelgrass beds, damage to eelgrass due to subsequent water or wind shear against the sharp oyster shells, repeated mechanical raking or trampling, and impacts from predator exclusion netting) is also of concern, though few studies have documented impacts. Hydraulic dredges used to harvest oysters in coastal bays with eelgrass habitat can cause long-term adverse impacts to eelgrass beds by reducing or eliminating the beds (Phillips 1984).

The rearing of non-native, ecologically undesirable species may pose a risk of escape or accidental release into areas where they would adversely affect the ecological balance. Escape or other release into the environment can result in competition with native, wild species for food, mates, and spawning sites, which, if followed by successful interbreeding with wild stocks, can result in genetic dilution.

Concern has also been expressed about extensive shellfish culture in estuaries and its impact on estuarine food webs. Oysters are efficient filter feeders and can change the trophic structure by removal of the microalgae and zooplankton that are also the food source for salmon prey species. The extent of this effect, if any, is unknown, especially in light of the fact that native oysters were once present in large quantities and coexisted with other species. Furthermore, because bivalves remove suspended sediments and phytoplankton from the water column, mariculture may actually improve water quality in eutrophic areas and can assist in recycling nutrients from water column to the sediment (Emmett 2002).

Kelp is harvested for several reasons, which include directly obtaining its byproducts and as a substrate in the Pacific herring fishery. Harvesting can have a variety of possible impacts on the habitat functions provided by kelp canopies. For example, kelp provides refuge to prey resources used by some fish species. The kelp canopy also serves as habitat for canopy-dwelling invertebrates and can enhance fish recruitment and abundance. Removal of the canopy may affect some species by potentially displacing young-of-the-year or juvenile rockfishes, for example (Miller and Geibel 1973).

G.4.10.2 Recommended Conservation Measures

The recommended conservation measures for commercial utilization of habitat include the following:

1. Site mariculture operations away from exisiting kelp or eelgrass beds. If mariculture operations are to be located adjacent to existing kelp or eelgrass beds, monitor these beds on an annual basis and resite the mariculture facility if monitoring reveals adverse effects.
2. Do not enclose or impound tidally influenced wetlands for mariculture. Take into account the size of the facility, migratory patterns, competing uses, hydrographic conditions, and upstream uses when siting facilities.
3. Undertake a thorough scientific review and risk assessment before any non-native species are introduced.
4. Encourage development of harvesting methods to minimize impacts on plant communities and the loss of food and/or habitat to fish populations during harvesting operations.
5. Provide appropriate mitigation for the unavoidable, extensive, or permanent loss of plant communities.

G.5 COASTAL/MARINE ACTIVITIES

G.5.1 Point-source Discharges

Point-source discharges from municipal sewage treatment facilities or storm water discharges are controlled through EPA's regulations under the CWA and by state water regulations. The primary concerns associated with municipal point-source discharges involve treatment levels needed to attain acceptable nutrient inputs and overloading of treatment systems due to rapid development of the coastal zone. Storm drains are contaminated from communities using settling and storage ponds, street runoff, harbor activities, and honey buckets. Annually, wastewater facilities introduce large volumes of untreated excrement and chlorine through sewage outfall lines, as well as releasing treated freshwater into the nation's waters. This can significantly alter pH levels of marine waters (Council 1999).

G.5.1.1 Potential Adverse Impacts

There are many potential impacts from point-source discharge, but point-source discharges and resulting altered water quality in aquatic environments do not necessarily result in adverse impacts, either to marine resources or EFH. Because most point-source discharges are regulated by the state or EPA, effects to receiving waters are generally considered on a case-by-case basis. Point-source discharges can adversely affect EFH by (1) reducing habitat functions necessary for growth to maturity, (2) modifying community structure, (3) bioaccumulation, and (4) modifying habitat.

At certain concentrations, point-source discharges can alter the following properties of ecosystems and associated communities: diversity, nutrient and energy transfer, productivity, biomass, density, stability, connectivity, and species richness and evenness. Pollution effects may be related to changes in water flow, pH, hardness, dissolved oxygen, and other parameters that affect individuals, populations, and communities. Sewage, fertilizers, and de-icing chemicals (e.g., glycols, urea) are examples of common urban pollutants that decompose with high biological or chemical oxygen demand (Council 1999).

Point-source discharges, at certain concentrations, can alter the following characteristics of finfish, shellfish, and related organisms: growth, visual acuity, swimming speed, equilibrium, feeding rate, response time to stimuli, predation rate, photosynthetic rate, spawning seasons, migration routes, and resistance to disease and parasites. Additionally, zones of low dissolved oxygen resulting from their decomposition can retard growth of salmon eggs, larvae, and juveniles and may delay or block smolt and adult migration. Sewage and fertilizers also introduce nutrients that drive algal and bacterial blooms into urban drainages. Such blooms may smother incubating salmon or produce toxins as they grow and die. Thermal effluents from industrial sites and removal of riparian vegetation from streambanks can degrade salmon habitat by allowing solar warming of water. Heavy metals, petroleum hydrocarbons, chlorinated hydrocarbons, and other chemical wastes can be toxic to salmonids and their food, and they can inhibit salmon movement and habitat use in streams (Council 1999).

Elevated salinity levels from desalination plants also have to be considered. While studies have shown that elevated salinity levels may not produce toxic effects (Bay and Greenstein 1994), peripheral effects of pollution may include forcing rearing fish into areas of high predation. Conversely, an influx of treated freshwater from municipal wastewater plants may force rearing fish into habitat with less than optimal salinity for growth (Council 1999).

Point discharges may affect the growth, survival, and condition of managed species and prey species if high levels of contaminants (e.g., chlorinated hydrocarbons, trace metals, PAHs, pesticides, and herbicides) are discharged. If contaminants are present, they may be absorbed across the gills or concentrated through bioaccumulation as contaminated prey is consumed (Raco-Rands 1996). Many heavy metals and persistent organic compounds such as pesticides and polychlorinated biphenyls tend to adhere to solid particles discharged from outfalls. As the particles are deposited, these compounds or their degradation products (which may be equally or more toxic than the parent compounds) can enter the foodchain by bioaccumulating in benthic organisms at much higher concentrations than in the surrounding waters (Stein et al. 1995). Due to burrowing, diffusion, and other upward transport mechanisms that move buried contaminants to the surface layers and eventually to the water column, pelagic and nektonic biota may also be exposed to contaminated sediments through mobilization into the water column.

Discharge sites may also modify habitat by creating adverse impacts to sensitive areas such as freshwater shorelines and wetlands, emergent marshes, sea grasses, and kelp beds if located improperly. Extreme discharge velocities of effluent may also cause scouring at the discharge point, as well as entraining particulates and thereby creating turbidity plumes. These turbidity plumes of suspended particulates can reduce light penetration and lower the rate of photosynthesis and the primary productivity of an aquatic area while elevated turbidity persists. The contents of the suspended material can react with the dissolved oxygen in the water and result in oxygen depletion, or smother submerged aquatic vegetation sites including eelgrass beds and kelp beds. Accumulation of outfall sediments may also alter the composition and abundance of infaunal or epibenthic invertebrate communities (Ferraro et al. 1991). Pollutants, either suspended in the water column (e.g., nitrogen, contaminants, fine sediments) or settled on the bottom, can affect habitat. Many benthic organisms are quite sensitive to grain size, and accumulation of sediments can also submerge food organisms (Section G.4.2.2).

G.5.1.2 Recommended Conservation Measures

The recommended conservation measures for point-source discharges include the following:

1. Locate discharge points in coastal waters well away from shellfish beds, sea grass beds, coral reefs, and other similar fragile and productive habitats.
2. Reduce potentially high velocities by diffusing effluent to acceptable velocities.

3. Determine benthic productivity by sampling before any construction activity related to installation of new or modified facilities. Develop outfall design (e.g., modeling concentrations within the predicted plume or likely extent of deposition along a productive nearshore) with input from appropriate resource and Tribal agencies.
4. Provide for mitigation when degradation or loss of habitat occurs from placement and operation of the outfall structure and pipeline.
5. Institute source-control programs that effectively reduce noxious materials to avoid introducing these materials into the waste stream.
6. Ensure compliance with pollutant discharges regulated through discharge permits which set effluent discharge limitations and/or specify operation procedures, performance standards, or BMPs. These efforts rely on the implementation of BMPs to control polluted runoff (EPA 1993).
7. Treat discharges to the maximum extent practicable, including implementation of up-to-date methodologies for reducing discharges of biocides (e.g., chlorine) and other toxic substances.
8. Use land-treatment and upland disposal/storage techniques where possible. Limit the use of vegetated wetlands as natural filters and pollutant assimilators for large-scale discharges to those instances where other less damaging alternatives are not available, and the overall environmental and ecological suitability of such actions has been demonstrated.
9. Avoid siting pipelines and treatment facilities in wetlands and streams. Since pipelines and treatment facilities are not water-dependent with regard to positioning, it is not essential that they be placed in wetlands or other fragile coastal habitats. Avoiding placement of pipelines within streambeds and wetlands will also reduce inadvertent infiltration into conveyance systems and retain natural hydrology of local streams and wetlands.

G.5.2 Fish Processing Waste—Shoreside and Vessel Operation

Seafood processing facilities are either shore-based facilities discharging through stationary outfalls or mobile vessels engaged in the processing of fresh or frozen seafood (Science Applications International Corporation [SAIC] 2001). Discharge of fish waste from shoreside and vessel processing has occurred in marine waters since the 1800s (Council 1999). With the exception of fresh market fish, some form of processing involving butchering, evisceration, precooking, or cooking is necessary to bring the catch to market. Precooking or blanching facilitates the removal of skin, bone, shell, gills, and other materials. Depending on the species, the cleaning operation may be manual, mechanical, or a combination of both (EPA 1974). Seafood processing facilities generally consist of mechanisms to offload the harvest from fishing boats; tanks to hold the seafood until the processing lines are ready to accept them; processing lines, process water, and waste collection systems; treatment and discharge facilities; processed seafood storage areas; and necessary support facilities such as electrical generators, boilers, retorts, water desalinators, offices, and living quarters. In addition, marinas that cater to patrons who fish a large amount can produce an equally large quantity of fish waste at the marina from fish cleaning.

G.5.2.1 Potential Adverse Impacts

Generally, seafood processing wastes consist of biodegradable materials that contain high concentrations of soluble organic material. Seafood processing operations have the potential to adversely affect EFH through (1) direct and/or nonpoint source discharge, (2) particle suspension, and (3) increased turbidity and surface plumes.

Seafood processing operations have the potential to adversely affect EFH through the direct and/or nonpoint source discharge of nutrients, chemicals, fish byproducts, and "stickwater" (water and entrained organics originating from the draining or pressing of steam-cooked fish products). EPA investigations show that impacts affecting water quality are direct functions of the receiving waters. In areas with strong currents and high tidal ranges, waste materials disperse rapidly. In areas of quieter waters, waste materials can accumulate and result in shell banks, sludge piles, dissolved oxygen depressions, and associated aesthetic problems (Stewart and Tangarone 1977). If adequate disposal facilities are not available at marinas that generate a large amount of fish waste, there is a potential for disposal of fish waste in areas without enough flushing to prevent decomposition and the resulting dissolved oxygen depression (EPA 1993).

Processors discharging fish waste are required to have EPA-issued NPDES permits. Various water quality standards, including those for biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform (FC) bacteria, oil and grease, pH, and temperature, are all considerations in the issuance of such permits. Although fish waste, including heads, viscera, and bones, is biodegradable, fish parts that are ground to fine particles may remain suspended for some time, thereby overburdening habitats from particle suspension (Council 1999). Such pollutants have the potential to adversely impact EFH. The wide differences in habitats, types of processors, and seafood processing methods define those impacts and can also prevent the effective use of technology-based effluent limits.

In Alaska, seafood processors are allowed to deposit fish parts in a zone of deposit (ZOD) (EPA 2001). This can alter benthic habitat, reduce locally associated invertebrate populations, and lower dissolved oxygen levels in overlying waters. Impacts from accumulated processing wastes are not limited to the area covered by the ZOD. Severe anoxic and reducing conditions occur adjacent to effluent piles (EPA 1979). Examples of localized damage to benthic environment include several acres of bottomdriven anoxic by piles of decomposing waste up to 26 feet (7.9 meters) deep. Juvenile and adult stages of flatfish are drawn to these areas for food sources. One effect of this attraction may lead to increased predation on juvenile fish species by other flatfishes, diving seabirds, and marine mammals drawn to the food source (Council 1999). However, due to the difficulty in monitoring these areas, impacts to species can go undetected.

Scum and foam from seafood waste deposits can also occur on the water surface and/or increase turbidity. Increased turbidity decreases light penetration into the water column, reducing primary production. Reduced primary production decreases the amount of food available for consumption by higher trophic level organisms. In addition, stickwater takes the form of a fine gel or slime that can concentrate on surface waters and move onshore to cover intertidal areas.

G.5.2.2 Recommended Conservation Measures

The recommended conservation measures for fish processing waste include the following:

1. To the maximum extent practicable, base effluent limitations on site-specific water quality concerns.
2. To the maximum extent practicable, avoid the practice of discharging untreated solid and liquid waste directly into the environment. Encourage the use of secondary or wastewater treatment systems where possible.
3. Do not allow designation of new ZODs. Explore options to eliminate or reduce ZODs at existing facilities.
4. Control stickwater by physical or chemical methods.
5. Promote sound fish waste management through a combination of fish-cleaning restrictions, public education, and proper disposal of fish waste.
6. Encourage the alternative use of fish processing wastes (e.g., fertilizer for agriculture and animal feed).
7. Explore options for additional research. Some improvements in waste processing have occurred, but the technology-based effluent guidelines have not changed in 20 years.
8. Locate new plants outside rearing and nursery habitat. Monitor both biological and chemical changes to the site.

G.5.3 Water Intake Structures/Discharge Plumes

The withdrawal of riverine, estuarine, and marine waters by water intake structures is a common aquatic activity. Water may be withdrawn and used, for example, to cool power-generating stations and create temporary ice roads and ice ponds. In the case of power plants, the subsequent discharge of heated and/or chemically treated discharge water can also occur.

G.5.3.1 Potential Adverse Impacts

Water intake structures and effluent discharges can interfere with or disrupt EFH functions in the source or receiving waters by (1) entrainment, (2) impingement, (3) discharge, (4) operation and maintenance, and (5) construction-related impacts.

Entrainment is the withdrawal of aquatic organisms along with the cooling water into the cooling system. These organisms are usually the egg and larval stages of managed species and their prey. Entrainment can subject these life stages to adverse conditions resulting from the effects of increased heat, antifouling chemicals, physical abrasion, rapid pressure changes, and other detrimental effects. Consequently, diverting water without adequate screening prevents that portion of EFH from providing important habitat functions necessary for the early life stages of managed living marine resources and their prey. Long-term water withdrawal may adversely affect fish and shellfish populations by adding another source of mortality to the early life stage, which often determines recruitment and year-class strength (Travnichek et al. 1993).

Impingement occurs when organisms that are too large to pass through in-plant screening devices become stuck against the screening device or remain in the forebay sections of the system until they are removed by other means (Grimes 1975, Hanson et al. 1977, Helvey and Dorn 1987, Helvey 1985, Langford et al. 1978, Moazzam and Rizvi 1980). The organisms cannot escape due to the water flow that either pushes them against the screen or prevents them from exiting the intake tunnel. Similar to entrainment, the withdrawal of water can trap particular species, especially when visual acuity is reduced (Helvey 1985). This condition reduces the ability of the source waters to provide normal EFH functions necessary for subadult and adult life stages of managed living marine resources and their prey.

Thermal effluents in inshore habitat can cause severe problems by directly altering the benthic community or killing marine organisms, especially larval fish. Temperature influences biochemical processes of the environment and the behavior (e.g., migration) and physiology (e.g., metabolism) of marine organisms (Blaxter 1969). Further, the proper functioning of sensitive areas may be affected by the action of intakes as selective predators, resulting in cascading negative consequences as observed by the overexploitation of local fish populations in coral-reef fish communities (Carr et al. 2002).

Other impacts to aquatic habitats can result from construction-related activities (e.g., dewatering, dredging, etc.) (Section G.4.1), as well as routine operation and maintenance activities. A broad range of impacts associated with these activities depend on the specific design and needs of the system. For example, dredging activities can cause turbidity, degraded water quality, noise, and substrate alterations. Many of these impacts can be reduced or eliminated through the use of various techniques, procedures, or technologies, but some may not be fully eliminated except by eliminating the activity itself.

Power plants may use once-through cooling biocides, such as sodium hypochlorite and sodium bisulfate, periodically to clean the intake and discharge structures. Chlorine is extremely toxic to aquatic life.

G.5.3.2 Recommended Conservation Measures

The recommended conservation measures for water intake structures and discharge plumes include the following:

1. Locate facilities that rely on surface waters for cooling in areas other than estuaries, inlets, heads of submarine canyons, rock reefs, or small coastal embayments where managed species or their prey concentrate. Locate discharge points in areas with low concentrations of living marine resources. Incorporate cooling towers at discharge points to control temperature, and use enough safeguards to ensure against release of blow-down pollutants into the aquatic environment in concentrations that reduce the quality of EFH.
2. Design intake structures to minimize entrainment or impingement. Use velocity caps that produce horizontal intake/discharge currents and ensure that intake velocities across the intake screen do not exceed 0.5 foot (0.15 meter) per second.
3. Design power plant cooling structures to meet the best technology available (BTA) requirements as developed pursuant to Section 316(b) of the CWA. Use alternative cooling strategies, such as closed cooling systems (e.g., dry cooling), to completely avoid entrainment or impingement impacts in all industries that require cooling water. When alternative cooling strategies are not feasible, other BTAs may include, but are not limited to, fish diversion or avoidance systems, fish return systems that convey organisms away from the intake, mechanical screen systems that prevent organisms from entering the intake system, and habitat restoration measures.
4. Regulate discharge temperatures (both heated and cooled effluent) so they do not appreciably alter the temperature to an extent that could cause a change in species assemblages and ecosystem function in the receiving waters. Implement strategies to diffuse the heated effluent.
5. Avoid the use of biocides (e.g., chlorine) to prevent fouling where possible. Implement the least damaging antifouling alternatives.
6. Mitigate for impacts related to power plants and other industries requiring cooling water. Ensure that mitigation compensates for the net loss of EFH habitat functions from placement and operation of the intake and discharge structures. Provide mitigation for the loss of habitat from placement of the intake structure and delivery pipeline, the loss of fish larvae and eggs that may be entrained by large intake systems, and the degradation or loss of habitat from placement of the outfall structure and pipeline, as well as the treated water plume.
7. Treat all discharge water from outfall structures to meet state water quality standards at the terminus of the pipe. Ensure that pipes extend a substantial distance offshore and are buried deep enough not to affect shoreline processes. Set buildings and associated structures far enough back from the shoreline to preclude the need for bank armoring.

G.5.4 Oil/Gas Exploration/Development/Production

Offshore exploration, development, and production of natural gas and oil reserves have been, and continue to be, an important aspect of the U.S. economy. As demand for energy resources grows, the debate over trying to balance the development of oil and gas resources and the protection of the environment will also continue. Projections indicate that U.S. demand for oil will increase by 1.3 percent per year between 1995 and 2020. Gas consumption is projected to increase by an average of 1.6 percent during the same time frame (Waisley 1998). Much of the 1.9 billion acres within the offshore jurisdiction of the U.S. remains unexplored (Oil and Gas Technologies for the Arctic and Deepwater [OGTAD] 1985). Some of the older oil and gas platforms in operation will probably reach the end of their productive life in the near future, and decommissioning them is also an issue.

G.5.4.1 Potential Adverse Impacts

Offshore oil and gas operations can be classified into exploration, development, and production activities (which includes transportation). These activities occur at different depths in a variety of habitats. These areas are subject to an assortment of physical, chemical, and biological disturbances, including the following (Council 1999, Helvey 2002):

- Noise from seismic surveys, vessel traffic, and construction of drilling platforms or islands
- Physical alterations to habitat from the construction, presence, and eventual decommissioning and removal of facilities such as islands or platforms, storage and production facilities, and pipelines to onshore common carrier pipelines, storage facilities, or refineries
- Waste discharges, including well drilling fluids, produced waters, surface runoff and deck drainage, domestic waste waters generated from the offshore facility, solid waste from wells (drilling muds and cuttings), and other trash and debris from human activities associated with the facility
- Oil spills
- Platform storage and pipeline decommissioning

Not all of the potential disturbances in this list apply to every type of activity.

Noise generates sound pressure that may disrupt or damage marine life. Oil and gas activities may generate noise from drilling activities, construction, production facility operations, seismic exploration, and supply vessel and barge movements. Research suggests that the noise from seismic surveys associated with oil exploration may cause fish to move away from the acoustic pulse and display an alarm response (McCauley et. al. 2000). This affects both fish distribution and catch rates (Engas et. al 1996). However, while there are few disagreements that noise from seismic surveys affects the behavior of fish, there are differences of opinion regarding the magnitude of those effects (McCauley et. al 2003, Gausland 2003, Wardle 2001).

Activities such as vessel anchoring, platform or artificial island construction, pipeline laying (Section G.4.9), dredging, and pipeline burial can change bottom habitat by altering substrates used for feeding or shelter. Disturbances to the associated epifaunal communities, which may provide feeding or predator escape habitat, may also result. Benthic organisms, especially prey species, may recolonize disturbed areas, but this may not occur if the substrate composition is drastically changed or if facilities are left in place after production ends. Dredging, trenching, and pipelaying generate spoils that may be disposed of on land or in the marine environment where sedimentation may smother benthic habitat and organisms. Most activities associated with oil and gas operations are, however, conducted under permits and regulations that require companies to minimize impacts or to avoid construction or other disturbances in sensitive marine habitats (Section G.4.2.2).

EPA and the state of Alaska issue permits for discharge of drilling muds and cuttings to ensure the activities meet Alaska water quality standards. Potentially, the discharge of muds and cuttings from exploratory and construction activities may, change the sea floor and suspend fine-grained mineral particles in the water column. This may affect feeding, nursery, and shelter habitat for various life stages of managed species. Drilling muds and cuttings may adversely affect bottom-dwelling organisms at the site by covering immobile forms or forcing mobile forms to migrate. Suspended particulates may reduce light penetration and lower the rate of photosynthesis and the primary productivity of the aquatic area, especially if suspended for long intervals. High levels of suspended particulates may reduce feeding ability for groundfish and other fish species, leading to limited growth. The contents of the suspended material may react with the dissolved oxygen in the water and result in oxygen depletion. In addition, the discharge of oil drilling muds can change the chemical and physical characteristics of benthic sediments at the disposal site by introducing toxic chemical constituents. Changes in water clarity and the addition of contaminants may reduce or eliminate the suitability of water bodies as habitat for fish species and their prey (NMFS 1998, a, b).

Federal and state laws and regulations require numerous oil spill prevention and cleanup response measures. The industry takes the initiative to prevent oil spills and uses the most current BMPs and state-of-the-art technology in oil spill prevention and response. Spills from oil and gas development remain, a potential source of contamination to the marine environment. Offshore oil and gas development, in any given geographic area, may result in some amount of oil entering the environment. Most spills are small, although large spills sometimes occur. Many factors determine the degree of damage from a spill, including the type of oil, size and duration of the spill, its geographic location, and the season. Oil is toxic to all marine organisms at high concentrations, but certain species are more sensitive than others. In general, the early life stages (eggs and larvae) are most sensitive, juveniles are less sensitive, and adults are least sensitive (Rice et al. 2000).

Both large and small quantities of oil can affect habitats and living marine resources. In addition, oil spills may interrupt commercial or subsistence fishing activities. Accidental discharge of oil can occur during almost any stage of exploration, development, or production on the outer continental shelf (OCS) or in nearshore coastal areas. Sources include equipment malfunction, ship collisions, pipeline breaks, other human error, or severe storms. Support activities associated with product recovery and transportation may also contribute to oil spills. In addition to crude oil, chemical, diesel, and other contaminant spills, accidental discharge can also occur (Council 1999).

Chronic small oil spills are a potential problem because residual oil can build up in sediments and affect living marine resources. Low levels of petroleum components (e.g., PAHs) from such chronic pollution may accumulate in fish tissues and cause lethal and sublethal effects, particularly during embryonic development. Low-level chronic exposure alters embryonic development in fish, resulting in reductions in growth and subsequent marine survival (Carls et al. 1999, Heintz et al. 1999, 2000).

A major oil spill (e.g., 50,000 barrels) can produce a surface slick covering several hundred square kilometers. If the oil spill moves toward land, habitats and species could be affected by oil reaching the near-shore environment. Immediately after a large spill, aromatic hydrocarbons would be toxic to some organisms. Waters beneath and surrounding the surface slick would be oil-contaminated. Physical and biological forces act to reduce oil concentrations with depth and distance (Council 1999); generally the lighter-fraction aromatic hydrocarbons evaporate rapidly, particularly during high winds and wave activity. Heavier oil fractions may settle through the water column. Suspended sediment can adsorb and carry oil to the seabed. Hydrocarbons may be solubilized by wave action, which may enhance adsorption to sediments. The sediments then sink to the seabed, contaminating benthic sediments.

Carls et al. (2003) demonstrated that tides and the resultant hydraulic gradients move groundwater containing soluble and slightly soluble contaminants (such as oil) from beaches surrounding streams into the hyporheic zone (the region beneath and next to streams where surface and groundwater mix) where pink salmon eggs incubate. Oil reaching nearshore areas will affect productive nursery grounds or areas containing high densities of fish eggs and larvae. An oil spill near an especially important habitat (e.g., a gyre where fish or invertebrate larvae are concentrated) could cause a disproportionately high loss of a population of marine organisms. Other aquatic biota at risk would be eggs, larvae, and planktonic organisms in the upper seawater column. Because they are small, they absorb contaminants quickly. They are also at risk because they cannot actively avoid exposure. Their proximity to the seasurface may make them vulnerable to photo-enhanced toxicity effects, which can multiply the toxicity of hydrocarbons (Barron et al. 2003). Population reductions due to delayed and indirect effects of PAH in tidal sediments postponed recovery among some species for more than a decade following the *Exxon Valdez* oil spill (Peterson et al. 2003).

Habitats that are susceptible to damage from oil spills include not just the low-energy coastal bays and estuaries where oil may accumulate, but also high-energy cobble environments where wave action drives oil into sediments. Many of the beaches in Prince William Sound with the highest persistence of oil following the *Exxon Valdez* oil spill were high-energy environments containing large cobbles overlain with boulders. These beaches were pounded by storm waves that drove the oil into and well below the surface (Michel and Hayes 1999). Oil that mixes into bottom sediments may persist for years. Subsurface oil was still detected in beach sediments of Prince William Sound 12 years after the *Exxon Valdez* oil spill, much of it unweathered and more prevalent in the lower intertidal biotic zone than at higher tidal elevations (Short et al. 2002, 2004). The unknown impact of an oil-related event near and within ice is an added concern. Should oil become trapped in ice, it could affect habitat for months or years after the initial event. It could also move into a different region (Council 1999).

Oil and gas platforms may consist of a lattice-work of pilings, beams, and pipes that support diverse fish and invertebrate populations and are considered de facto artificial reefs (Love and Westphal 1990, Love et al. 1994, Love et al. 1999, Helvey 2002). Because decommissioning includes plugging and abandoning all wells and removing the platforms and associated structures from the ocean, impacts to EFH are possible during removal. The demolition phase may generate underwater sound pressure waves (Section G.4.5.2), impacting on marine organisms. Taking out these midwater structures may remove habitat for invertebrates and fish that associate with them. In some areas of the U.S., offshore oil and gas platforms are left in place after decommissioning, thereby providing permanent habitat for some organisms.

The potential disturbances and associated adverse impacts on the marine environment have been reduced through operating procedures required by regulatory agencies and, in many cases, self-imposed by facilities operators. Most of the activities associated with oil and gas operations are conducted under permits and regulations that require companies to minimize impacts or avoid construction in sensitive marine habitats. For example, the discharge of muds and cuttings is subject to EPA environmental standards, effluent limitations, and related requirements. New technological advances in operating procedures also reduce the potential for impacts.

G.5.4.2 Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH:

1. As part of pre-project planning, identify all species of concern regulated under federal or state fishery management plans that inhabit, spawn, or migrate through areas slated for exploration, development, or production. Pay particular attention to critical life stages, and develop options that avoid and minimize adverse effects from any associated activities. Modify the project design, timing, or location and use adaptive management.
2. Avoid the discharge of produced waters into marine waters and estuaries. Reinject produced waters into the oil formation whenever possible.
3. Avoid discharge of muds and cuttings into the marine and estuarine environment. Use methods to grind and reinject such wastes down an approved injection well or use onshore disposal wherever possible. When not possible, provide for a monitoring plan to ensure that the discharge meets EPA effluent limitations and related requirements.
4. To the extent practicable, avoid the placement of fill to support construction of causeways or structures in the nearshore marine environment.
5. As required by federal and state regulatory agencies, encourage the use of geographic response strategies that identify EFH and environmentally sensitive areas. Identify appropriate cleanup methods and response equipment.

6. To the extent practicable, use methods to transport oil and gas that limit the need for handling in environmentally sensitive areas, including EFH.
7. Ensure that appropriate safeguards have been considered before drilling the first development well into the targeted hydrocarbon formations whenever critical life history stages of federally managed species are present.
8. Ensure that appropriate safeguards have been considered before drilling exploration wells into untested formations whenever critical life stages of federally managed species are present. If possible, avoid such work entirely during those time frames.
9. Oil and gas transportation and production facilities should be designed, constructed, and operated in accordance with applicable regulatory and engineering standards.
10. Evaluate impacts to EFH during the decommissioning phase of oil and gas facilities, including possible impacts during the demolition phase. Minimize such impacts to the extent practicable.

G.5.5 Habitat Restoration/Enhancement

Habitat loss and degradation are major, long-term threats to the sustainability of fishery resources (NMFS 2002). Viable coastal and estuarine habitats are important to maintaining healthy fish stocks. Good water quality and quantity, appropriate substrate, ample food sources, and substantial hiding places are needed to sustain fisheries. Restoration and/or enhancement of coastal and riverine habitat that supports managed fisheries and their prey will assist in sustaining and rebuilding fisheries stocks and recovering certain threatened or endangered species by increasing or improving ecological structure and functions. Habitat restoration/enhancement may include, but is not limited to, improvement of coastal wetland tidal exchange or reestablishment of historic hydrology, dam or berm removal, fish passage barrier removal/ modification, road-related sediment source reduction, natural or artificial reef/substrate/habitat creation, establishment or repair of riparian buffer zones, improvement of freshwater habitats that support anadromous fishes, planting of native coastal wetland and submerged aquatic vegetation, creation of oyster reefs, and improvements to feeding, shade or refuge, spawning, and rearing areas that are essential to fisheries.

G.5.5.1 Potential Adverse Impacts

The implementation of restoration/enhancement activities may have localized and temporary adverse impacts on EFH. Possible impacts can include (1) localized nonpoint source pollution such as influx of sediment or nutrients, (2) interference with spawning and migration periods, (3) temporary or permanent removal feeding opportunities, and (4) indirect effects from actual construction portions of the activity.

Unless proper precautions are taken, upland-related restoration projects can contribute to nonpoint source pollution. Such concerns should be addressed as part of the planning process (Section G.2.1). Particular in-water projects may interfere with spawning periods or impede migratory corridors and should be addressed accordingly. Projects may also have an affect on the feeding behavior of managed species. For instance, if dredging is involved, benthic food resources may be affected (Section G.4.1). Impacts can occur from individuals conducting the restoration, especially at staging areas; as part of accessing the restoration site; or due to the actual restoration techniques employed. Particular water quality impacts can derive from individuals conducting the restoration, excessive foot traffic, diving techniques, equipment handling, boat anchoring, and planting techniques.

Habitat restoration activities that include the removal of invasive species may cause minor disturbances of native species. For example, netting and trapping of invasive fish species may result in unwanted bycatch of native fish and other aquatic species. Fish passage restoration and other hydrologic restoration activities, such as the removal of culverts or other in-stream structures, installation of fishways, or other in-water activities will require temporary rerouting of flows around the project area. This could temporarily disturb on-site or adjacent habitats by altering hydrologic conditions and flows during project implementation.

Artificial reefs are sometimes used for habitat enhancement, but can have negative effects. Impacts of artificial reefs on EFH may include loss of habitat upon which the reef material is placed or the use of inappropriate, damaging materials for construction. Usually, reef materials are set upon flat sand bottoms or "biological deserts," which end up burying or smothering bottom-dwelling organisms at the site or even preventing mobile forms (e.g., benthic-oriented fish species) from using the area as habitat. Some materials may be inappropriate for the marine environment (e.g., automobile tires or compressed incinerator ash) and can serve as sources of toxic releases or physical damage to existing habitat when breaking free of their anchoring systems (Collins et al. 1994).

G.5.5.2 Recommended Conservation Measures

The recommended conservation measures for habitat restoration and enhancement include the following:

1. Use BMPs to minimize and avoid potential impacts to EFH during restoration activities. BMPs should include, but are not limited to, the following:
   a) Use turbidity curtains, haybales, and erosion mats to protect the water column.
   b) Plan staging areas in advance, and keep them to a minimum size.
   c) Establish buffer areas around sensitive resources; flag and avoid rare plants, archeological sites, etc.
   d) Remove invasive plant and animal species from the proposed action area before starting work. Plant only native plant species. Identify and implement measures to ensure native vegetation or revegetation success (Section G.4.4).
   e) Establish temporary access pathways before restoration activities to minimize adverse impacts from project implementation.
2. Avoid restoration work during critical life stages for fish such as spawning, nursery, and migration. Determine these periods before project implementation to reduce or avoid any potential impacts.
3. Provide adequate training and education for volunteers and project contractors to ensure minimal impact to the restoration site. Train volunteers in the use of low-impact techniques for planting, equipment handling, and any other activities associated with the restoration.
4. Conduct monitoring before, during, and after project implementation to ensure compliance with project design and restoration criteria. If immediate post-construction monitoring reveals that unavoidable impacts to EFH have occurred, ensure that appropriate coordination with NMFS occurs to determine appropriate response measures, possibly including mitigation.
5. To the extent practicable, mitigate any unavoidable damage to EFH within a reasonable time after the impacts occur.
6. Remove and, if necessary, restore any temporary access pathways and staging areas used in the restoration effort.
7. Determine benthic productivity by sampling before any construction activity in the case of subtidal enhancement (e.g., artificial reefs). Avoid areas of high productivity to the maximum extent possible. Develop a sampling design with input from state and federal resource agencies. Before construction, evaluate of the impact resulting from the change in habitat (sand bottom to rocky reef, etc.). During post-construction monitoring, examine the effectiveness of the structures for increasing habitat productivity.

G.5.6 Marine Mining

Mining activity, which is also described in Sections G.3.1.1 and G.3.1.2, can lead to the direct loss of EFH for certain species. Offshore mining, such as the extraction of gravel and gold in the Bering Sea

(EBS) and the mining gravel of gravel from beaches, can increase turbidity of water. Thus, the resuspension of organic materials could affect less motile organisms (i.e., eggs and recently hatched larvae) in the area. Benthic habitats could be damaged or destroyed by these actions. Mining large quantities of beach gravel may significantly affect the removal, transport, and deposition of sand and gravel along the shore, both at the mining site and down-current (Council 1999). Neither the future extent of this activity nor the effects of such mortality on the abundance of marine species is known.

G.5.6.1 Potential Adverse Impacts

Mining practices that can affect EFH include physical impacts from intertidal dredging and chemical impacts from the use of additives such as flocculates (Council 1999). Impacts may include the removal of substrates that serve as habitat for fish and invertebrates; habitat creation or conversion in less productive or uninhabitable sites, such as anoxic holes or silt bottom; burial of productive habitats, such as in near-shore disposal sites (as in beach nourishment); release of harmful or toxic materials either in association with actual mining, or in connection with machinery and materials used for mining; creation of harmful turbidity levels; and adverse modification of hydrologic conditions so as to cause erosion of desirable habitats. Submarine disposal of mine tailings can also alter the behavior of marine organisms. Submarine mine tailings may not provide suitable habitat for some benthic organisms. In laboratory experiments, benthic dwelling flatfishes (Johnson et al. 1998a) and crabs (Johnson et al. 1998b) strongly avoided mine tailings.

During beach gravel mining, water turbidity increases and the resuspension of organic materials can affect less motile organisms (i.e., eggs and recently hatched larvae) in the area. Benthic habitats can be damaged or destroyed by these actions. Changes in bathymetry and bottom type may also alter population and migrations patterns (Hurme and Pullen 1988).

G.5.6.2 Recommended Conservation Measures

The following recommended conservation measures for marine mining should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. To the extent practicable, avoid mining in waters containing sensitive marine benthic habitat including EFH (e.g., spawning, migrating, and feeding sites).
2. Minimize the areal extent and depth of extraction to reduce recolonization times.
3. Monitor turbidity during operations, and cease operations if turbidity exceeds predetermined threshold levels. Use sediment or turbidity curtains to limit the spread of suspended sediments and minimize the area affected.
4. Monitor individual mining operations to avoid and minimize cumulative impacts. For instance, three mining operations in an intertidal area could impact EFH, whereas one may not. Disturbance of previously contaminated mining areas may cause additional loss of EFH.
5. Use seasonal restrictions, as appropriate, to avoid and minimize impacts to EFH during critical life history stages of managed species (e.g., migration and spawning).

G.5.7 Persistent Organic Pollutants

The single biggest pollution threat to marine waters in Alaska is the deposition of persistent pollutants from remote sources. North Pacific and Alaska marine waters are perceived as pristine because most of Alaska's 6,640 miles (10,686 kilometers) of coastline are devoid of point-source pollution, unlike much of North America. Effluents from pulp mills, marinas and boat harbors, municipal outfalls, and other industrial activities are generally considered to be the primary sources of contamination in Alaska waters, so most efforts at monitoring and mitigation have been focused on the local level. The only major regional pollution event was the *Exxon Valdez* oil spill in 1989, a contaminant threat that has abated considerably over the last 14 years. However, there is an increasing body of evidence suggesting that the greatest contaminant threat in Alaska comes from atmospheric and marine transport of contaminants from areas quite distant from Alaska.

The geography of Alaska makes it particularly vulnerable to contaminants volatilized from Asia. During winter, the Aleutian low pressure cell steers air from Southeast Asia into the EBS and northern Gulf of Alaska (GOA), bringing precipitation along the way. When this air meets the mountains along Alaska's southern coast, more precipitation occurs, bringing entrained contaminants from the atmosphere into the marine ecosystem or coastal/interior ecosystems. Thus, pesticides applied to crops in Southeast Asia can be volatilized into the air, bound to suspended particulates, transported in the atmosphere to Alaska, and deposited in snow or rain directly into marine ecosystems or indirectly from freshwater flow to nearshore waters. Revolatilization of these compounds is inhibited by the cold temperatures associated with Alaska latitudes, resulting in a net accumulation of these compounds in northern habitats. This same distillation process also transfers volatilized contaminants from the atmosphere to the Pacific at lower latitudes, and ocean currents also deliver the contaminants to Alaska. Concentrations will be very low, but there will extensive geographical marine or land areas to act as cold deposit zones.

G.5.7.1 Potential Adverse Impacts

The effect of these transport mechanisms has been the appearance of persistent organic contaminants in northern latitudes, despite the absence of local sources. A good demonstration of global transport into northern latitudes is the presence of dichloro-diphyl-trichloroethanes (DDTs) in the blubber of ring seals in the western Canadian Arctic (Addison and Smith 1996). DDT and its congeners were first observed in these seals during the early 1970s. The persistence DDTs in these seals through the 1990s, despite North American bans on DDT use in the1970s, is evidence of continued deposition of DDT from countries still using this pesticide.

The existence of organic contaminants in biological tissues means these contaminants are being transported within the food webs in Alaska fish habitats. For example, Ewald et al. (1998) found detectable levels of polychlorinated biphenyls (PCBs), DDTs, and other pesticides in the tissues of adult sockeye salmon returning to the Copper River. These fish apparently concentrated these contaminants in their tissues during their migration in the northern GOA and delivered them to their spawning habitats in the interior of Alaska. Avian and mammalian predators of these fish would further distribute these contaminants.

G.5.7.1.1 Distribution of Contaminants in Marine Habitats

A large variety of contaminants can be found in Alaska's marine environment, including persistent organic pollutants (POPs) and heavy metals. POPs are characterized as those with half-lives over 2 months, bioaccumulation factors greater than 5,000, potential for long-range transport, and capable of toxic effects. Currently, 12 classes of compounds are considered POPs and are regulated by the Stockholm Convention on Persistent Organic Pollutants (Table 5.7-1). In addition to POPs, heavy metals present in Alaska habitats include mercury (Hg), cadmium (Cd), chromium (Cr), arsenic (As), lead (Pb), and silver (Ag). Contaminants found in Alaska marine mammals sampled between southeastern Alaska and the Aleutian and Pribilof Islands include PCBs, DDT, chlordanes, hexachlorocyclohexanes (HCHs), hexachlorobenzene (HCB), dieldrin, butyltins, arsenic, mercury, cadmium, and lead (Barron and Heintz in press). With over 100,000 chemicals on the market and an additional 1,000 to 2,000 new ones introduced annually, there are likely other toxic compounds in the environment whose concentrations are increasing.

In addition, combustion and industrial processes result in the inadvertent production of unregulated chemicals (Arctic Monitoring and Assessment Programme [AMAP] 2002).

There have been few large-scale evaluations of the spatial or temporal patterns to contamination in Alaska's marine environment. Most effort at monitoring contaminant loads in Alaska waters has focused on Arctic habitats where there is evidence that PCBs and DDTs have declined over the last 25 years (AMAP 2002). Recently, Beckmen et al. (2001) reported on the concentrations of PCBs in sea lion scats collected from around the GOA. These data suggest that sea lion prey in the eastern Aleutian Islands (AI) have greater PCB loads than prey near Kodiak, Cook Inlet, and Prince William Sound. Prey from the latter three locations also have lower PCB loads than those from southeastern Alaska. Some of the relatively high values observed in the eastern Aleutians may reflect the addition of PCB point-source inputs at specific sites (Barron and Heintz in press), but it would seem unlikely that a few point sources could account for the general elevated state of PCB loads in the entire Aleutians.

Table 5.7-1. The Twelve Persistent Organic Pollutants Regulated by the POPs Treaty

	Common Name	Effect on Organisms
Pesticides	Dieldrin	Reproductive impairment; renal and liver damage
	Aldrin	Neurological damage; reproductive impairment
	Chlordane	Altered hormone function
	DDT/DDE	Neurological damage; hormonal disruption; reproductive impairment
	Endrin	Developmental abnormalities
	Heptachlor	Liver damage; hormonal changes
	Hexachlorobenzene	Reduced embryo weights in herring gulls
	Mirex	Kidney lesions in fish
	Toxaphene	"Broken-back" syndrome in fish
Polychlorinated biphenyls	PCBs	Poor reproductive success Impaired immune function
Industrial and Incineration Byproducts	Dioxins	Immune suppression; hormonal dysfunction; developmental impairment
	Furans	Developmental impairment; increased abortions

Source: World Federation of Public Health Associations 2000. Persistent organic pollutants and human health. Washington, DC.

Temporal studies provide little information because they are quite limited as to the number of locations evaluated and the samples collected. The mechanism, however, by which contaminants are delivered to the Alaska marine environment guarantees that the contaminants will be found in Alaska waters for as long as they are released (Wania and Mackay 1999). For example, the types of PCBs found in seals from sites near the Russian coast are consistent with those used in Russian electrical equipment (Muir and Norstrom 2000). Contributions of contaminants by marine transport will continue for some time. More water-soluble organic contaminants like HCHs are slower to accumulate in Arctic and subarctic food webs and appear to be increasing (Wania and Mackay 1999). Mercury appears to be higher in more recent samples (mid 1990s) than in the 1980s and 1970s, and rates of Hg accumulation also appear to be higher than they were 10 to 20 years ago (Muir et al. 1999). Polybrominated diphenyl ethers (PBDEs) also appear to be increasing in marine mammals (Ikonomou et al. 2002) and may surpass PCBs as the most prevalent POP in arctic habitats.

G.5.7.1.2 Factors Leading to Higher Contaminant Loads

The trophic structure of Alaska marine food webs, coupled with the tendency of contaminants to accumulate in Alaska habitats, causes apex predators to concentrate significant amounts of POPs in their tissues. Organisms occupying the top trophic levels in a food web bioaccumulate the highest concentrations of contaminants (Ruus et al. 2002). For example, the total PCB concentration in seal-eating killer whales sampled near Kenai Fjords National Monument was one to two orders of magnitude greater than fish-eating killer whales, indicating the significance of their trophic position (Ylitalo et al. 2001a). Further, seal-eating killer whale PCB loads were greater than the loads typically associated with belugas from the St. Lawrence River, while those of resident, fish-eating killer whales were consistent with loads observed in harbor seals in Puget Sound (Ylitalo et al. 2001a). The few data available on organisms at lower trophic levels in Alaska's marine habitats indicate these species experience relatively low contaminant loads (de Brito et al. 2002, Aono et al. 1997, Kawano et al. 1986). Thus, Alaska killer whales are likely accumulating loads of contaminants from remote sources that are consistent with those of marine mammals living near heavily contaminated urban areas as a result of their high trophic position. While this interpretation fails to account for differences in life stage, sex, or analytical method, it illustrates the need for more detailed information about this region.

This issue is particularly relevant when the contaminant loads experienced by Alaska natives subsisting on foods derived from marine habitats are considered. In one study, the total PCB concentration (not lipid adjusted) in serum collected from Aleutian males, ages 45 to 54, averaged 8.7 parts per billion (Alaska Division of Public Health 2003). By comparison, the concentrations in similarly aged males from around the Great Lakes who also consumed large amounts of fish (more than 52 meals per year) averaged 4.8 parts per billion (Hanrahan et al. 1999). Reference males in the latter study were demographically similar, ate less fish, and averaged 1.5 parts per billion. The relatively high level for the Alaska natives is likely the result of their trophic position relative to that of the Great Lakes fishers. Alaska natives with subsistence lifestyles who live in the Aleutians probably consume seals and fish, leading to a trophic position above that of Great Lakes fishers, who likely consume more grains and plant materials than Aleutian natives.

A second contributing factor to increased contaminant loads among apex predators in Alaska is their relatively long life. Contaminant loads increase with age in fish (Vuorinen et al. 2002), Steller sea lions (O'Hara 2001, Ylitalo et al. 2001b), and humans (Alaska Division of Public Health 2003). Female pinnipeds in the EBS and northern GOA typically begin reproducing at 5 years of age (Riedman 1990), allowing time for significant accumulation of contaminants, especially because pinnipeds eat relatively large (i.e., old) prey. For example, the pollock consumed by Steller sea lions average 1.3 feet (393 mm) and Atka mackerel 1.06 feet (323 mm) (Zeppelin et al. 2003). This translates to fish ages of approximately 3 to 5 years old. These sizes, however, were at the low end of the size distribution, indicating that sea lions can eat much older prey. Vuorinen et al. (2002) reported a sevenfold increase in POP loads of sprat between ages 2 and 10, demonstrating the increased potential for exposure associated with consuming older prey.

G.5.7.1.3 Significance of Contaminant Loads

It is not clear if the levels of contaminants in Alaska waters are causing deleterious effects to populations, because research in this area is still in its infancy. Relatively small and spotty contaminant surveys have established that POPs are present in Alaska waters, forage, and predators. No comprehensive geographical and temporal studies have been done to date to examine trends or sources of variation. The potential for the problem has been exposed; the extent and significance remain to be determined.

The potential for significant effects is most likely greatest among apex predators. Contamination is probably widespread among forage species at low levels, but apex predators are likely be the most affected as a result of their longevity, lipid storage, and the relatively high concentrations they bear. In mammals, it is most likely that lipophilic contaminants would have the greatest impacts on first-born young. The accumulation contaminants in females increase with age, but decrease after females reach reproductive age. This is the result of their transfer of contaminants to their offspring in milk. This process has been reported for sea lions, fur seals (Beckmen et al. 1999), and humans (Yang et al. 2002).

This process occurs repeatedly for each offspring, consequently, the first-born offspring receives adult level contaminant loads during its most sensitive developmental stage. Beckmen et al. (1999) reported that first-born northern fur seal pups of primiparous mothers had higher PCB levels in their blood than pups of multiparous mothers. This higher load was correlated with a reduced ability to form antibodies to tentanus, along with reduced concentrations of thyroxine and vitamin A in their blood. Barron and Heintz (in press) compared reported PCB loads in juvenile Steller sea lions with loads known to cause deleterious effects in other pinnepeds and concluded that some sea lions in the mid-1980s likely experienced immunological impairment. Assessing impacts on humans is more difficult and controversial. While the acute impacts of contaminants on humans are known, the long-term impacts following neonatal exposure have not been explored.

Recent declines in apex predator populations in the EBS and northern GOA may be related to contaminant loading in the region. Over the last 25 years, the populations of Steller sea lions, harbor seals, northern fur seals, and many birds have declined. The reasons underlying these declines are likely complex and may not be the same for all species. For example, the decline in Steller sea lions is presumed to have resulted from nutritional stress, but more recent evidence suggests other factors, including contaminants, may be limiting their recovery (De Master et al. 2001). Contaminants are unlikely to be causing acutely toxic effects in the regions. Sublethal impacts of contaminants, however, could be working indirectly to impair populations through reduced immune function (Beckmen 2001) or reproduction (Reinjders 1986). Both of these characters are displayed by Steller sea lion populations from the affected region. York et al. (1996) attributed continuing declines in affected populations to a failure to recruit offspring to maturity. Zenteno-Savin et al. (1997) reported elevated levels of haptoglobin, an acute-phase reaction protein in the blood of Steller sea lions and harbor seals from affected populations relative to levels observed in stable or increasing populations. This protein is indicative of non-specific stressors that could include injury, disease, or toxicity. Thus, a recent panel was unable to reject contaminants as a factor contributing to the failed recovery of Steller sea lion populations (Barron and Heintz 2001).

Impacts may also occur at lower trophic levels, but there has been even less research in this area. Atlantic salmon in the Baltic Sea and salmonids in the Great Lakes have both experienced a common syndrome variously named M74 or early mortality syndrome. The syndrome is characterized by low thiamine content in eggs, resulting in near complete mortality of affected brood years. While the cause for the reduced thiamine content in spawning adults remains unknown, increased levels of PCB and dibenzofurans and dibenzo-dioxins were correlated with the onset of the disease in Baltic salmon (Vuorinen et al. 2002).

The impacts of persistent contaminants on populations in Alaska waters are not likely to be acute. The impacts are more likely be expressed as sublethal impacts in apparently healthy animals. These sublethal impacts ultimately lead to reduced reproductive fitness or decreased survival to maturity; therefore, they manifest themselves indirectly. Science is certain that the physical properties of these compounds couple with global climate patterns to ensure that they will be deposited in Alaska habitats, while maintaining their toxicity and perfusing through Alaska food webs, which include some of the most valuable fisheries on the planet. What is uncertain is how these compounds impact the health of organisms deriving sustenance from those food webs and how those impacts might feed back into the food web.

G.5.7.2 Recommended Conservation Measures

No mitigation strategies are proposed at this time relative to contaminants. There are too many unknowns. POP contaminants are present in Alaska waters and forage species and in predators up through apex predators, but the significance of the present loads is not known. Also, the relative concentrations in forage species (pollock for example) from the EBS, near Russia, or the northern GOA are not known. Comprehensive studies on a geographical, temporal, or widespread species scale to determine any relationship between contaminant loads and population changes have not been conducted. POP contaminants may contribute to poor recovery in some species, but mitigation strategies, whether they would be changes in fishing regulations or international regulation to curb contaminant releases, will likely need a better research foundation to support changes.

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Online Resources

BMPs are often specific to certain geographical locations or pesticide application programs, with the aim of reducing or eliminating pesticide transport to surface waters. An example of a pesticide use reduction strategy for a large city (Seattle) is available at http://www.metrokc.gov/hazwaste/ipm/.

Information can also be found at the following websites and in the following publications:

ADEC, Division of Environmental Health's Pesticide Control Program: http://www.state.ak.us/dec/eh/pest/index.htm

EPA. 1984. Best Management Practices for Agricultural Nonpoint Source Control: IV. Pesticides. EPA Number: 841S84107.

Dredging BMPs: http://www.spn.usace.army.mil/ltms2001/appi.pdf

Various integrated pest management strategies can be found at the following websites:

U.S. Department of Agriculture. Cooperative State Research, Education, and Extension (CSREES) Program: http://www.reeusda.gov/ipm

Federal and state invasive species activities and programs: http://www.invasivespecies.gov/new/whatsnew.shtml

Logging effects studies on fish habitat (bibliography): http://www.afsc.noaa.gov/abl/ habitat/pdfs/logging.pdf

The following links provide detailed standards and guidance:

Best Management Practices: http://www.fs.fed.us/r10/TLMP/F_PLAN/APPEND_C.PDF

Stream Process Groups: http://www.fs.fed.us/r10/TLMP/F_PLAN/APPEND_D.PDF

Watershed Analysis: http://www.fs.fed.us/r10/TLMP/F_PLAN/APPEND_J.PDF

Riparian: http://www.fs.fed.us/r10/ TLMP/F_PLAN/FPCHAP4.PDF

Transportation: http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF

Beach and Estuary Fringe: http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF

Fish: http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF

Wetlands: http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF

Soils and Water: http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF

Alaska's Invasive Species: http://www.adfg.state.ak.us/special/invasive/invasive.php

Aquatic Nuisance Species: http://www.anstaskforce.gov/

Alaska Department of Fish and Game and Alaska Department of Public Transportation of Public Facilities, Memorandum of Agreement for the Design, Permitting, and Construction of Culverts for Fish Passage. August 2001: http://www.sf.adg.state.ak.us/SARR/fishpassage/pdfs/dot_adfg_fishpass080301.pdf